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A NEW SUBSPECIES OF *AGRILUS* FROM TEXAS (COLEOPTERA: BUPRESTIDAE)

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Dr. H. F. Howden sent me a series of *Agrilus* which exhibit differences from typical *A. putillus* Say. It appears to be an isolated population worthy of a name.

Agrilus putillus parputillus n. subsp.

Male.—Form small, robust; shining cupreous throughout, with exception of bronze green front.

Head convex, with median longitudinal groove on occiput; surface finely transversely rugose on front, longitudinally rugose on occiput, clothed with short, recumbent pubescence on front; antennae extending past middle of pronotum when laid along side, serrate from fifth segment.

Pronotum wider than long, narrower at base than at apex, widest in basal half; sides diverging trom front angles to past middle, then broadly rounded and converging to base; when viewed from side, marginal and submarginal carinae are sinuate, separated in front and joined near base; anterior margin slightly sinuate, median lobe broad; basal margin bisinuate, median lobe subtruncate; disk convex, slightly flattened in front of scutellum, with large depression each side along lateral margin, prehumeral carinae lacking; surface coarsely transversely rugose, minute punctures between rugae, pubescence short, longer hairs in lateral depressions. Scutellum transversely carinate.

Elytra at base wider than base of pronotum; sides subparallel to behind middle, expanded back of middle, then converging to separately rounded, minutely serrulate apices; disk longitudinally depressed along sutural margin, basal depression on each elytron, an indistinct costa in middle of each elytron; surface rather coarsely imbricate, punctures minute and each bearing a short recumbent hair.

Abdomen beneath finely sparsely punctate; first ventral segment slightly flattened in middle, second segment convex. Prosternum densely pubescent, lobe strongly declivous, margin emarginate. Posterior coxae emarginate, outer angle not prolonged. Tibiae slender, front and middle pairs armed with a short curved tooth on inner margin at apex. Posterior tarsi shorter than tibiae. Tarsal claws similar on all feet, outer tooth long, acute, inner tooth short, broad, not turned inward. Genitalia quite similar to those of *A. putillus putillus*.

Length: 4.5 mm; width 1.3 mm.

Female.—Differs from male by being slightly larger, having head uniformly cupreous, prosternum not pubescent, lobe rounded and tibiae unarmed.

Holotype, allotype and paratypes collected on maple (*Acer grandidentatum* Nutt.) in Pine Canyon, Chisos Mountains, Big Bend National Park, Brewster Co., Texas, May 10, 1959; paratypes from same locality May 4 and 7; Boot Spring May 18 and Pulliam Canyon May 17, all in Chisos Mountains. Pupae were found in dead maple twigs. All material collected by H. F. Howden and E. C. Becker.

Holotype and one paratype will be deposited in U. S. National Museum, allotype and paratypes in Canadian National Collection, paratypes in Collection of The Ohio State University and author.

This subspecies differs from typical form by being slightly larger in size, cupreous in color, (*A. putillus putillus* is blackish brown), sculpture of pronotum and elytra much coarser and pubescence of elytra more evident, especially along suture margin.

A. putillus putillus breeds in *Acer saccharum* Marsh.

I express thanks to Drs. Howden and Becker for the privilege of describing this form.

A NEW CALIFORNIA *ACMAEODERA* (COLEOPTERA: BUPRESTIDAE)

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The following buprestids were found on flowers of buckwheat (*Eriogonium*) and are unlike any of our described species.

Acmaeodera santarosae n. sp.

Male.—Form of a small *A. gemina* Horn; head, thorax and ventral surface dark, shining bronze; elytra yellow, each elytron bearing two irregular blackish brown vittae, one along suture and one near outer margin.

Head convex; surface reticulate, clothed with long, recumbent white hairs; antennae extending to about middle of pronotum when laid along side, serrate from fifth segment, segments five to eleven inclusive more densely, minutely punctate.

Pronotum wider than long, widest in middle, base wider than apex; sides broadly rounded from apex to base, constricted at base, lateral margin not present; disk convex with transverse corrugated line at base, a small median depression in front of line at base, a larger depression each side near outer margin; surface densely reticulate, reticulation larger than on head, densely clothed with recumbent white hairs.

Elytra convex, near base wider than widest part of pronotum, widest back of base, sides rounded at base, subparallel back of base, constricted in basal third, then converging to separately rounded apices, side margins serrulate on apical third, disk convex, umbone prominent, surface striately punctured, punctures large, separated by less than own diameters, interspaces narrower than punctures, punctures of interspaces not visible, a line of short suberect well placed hairs in middle of each interspace.

Beneath prosternal margin retracted from side margin, slightly emarginate. Abdomen densely, minutely punctate, a recumbent white hair arising from each puncture, last sternite unmodified.

Length: 4.2 mm; width: 1.4 mm.

Female.—Differs from male by being larger, less cuneate; outer segments of antennae less transverse.

Described from a series collected at about 4,000 ft, on Santa Rosa Mountains, Riverside County, California, June 15, 1948 by D. J. and J. N. Knull.

Holotype, allotype and paratypes in my collection, paratype in collection of The Ohio State University.

This species superficially resembles *A. quadrivittata* Horn; however it can be separated by pronotal sculpture which is reticulate instead of punctured. From *A. gemina* Horn it differs by lacking yellow lateral spot on side of pronotum near apex, by less dense pubescence of elytra, and by being less convex.

The specimens vary in elytral color marking from yellow with dark suture, umbone and a trace back of umbone to typical marking.

ACANTHATRIUM LUNATUM N. SP., A PARASITE OF THE BIG BROWN BAT AND A KEY TO THE DESCRIBED SPECIES OF *ACANTHATRIUM*

(TREMATODA: LECITHODENDRIIDAE)

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Trematodes of the genus *Acanthatrium* Faust, 1919 have frequently been found in bats I have examined but not in so great a number as other lecithodendriid flukes. Species of *Acanthatrium* differ from other Lecithodendriinae in that each possesses pretesticular vitellaria and a genital atrium lined with spines. The species are separated within the genus mainly on the presence or absence of an esophagus, the character of the atrial spines, and the presence or absence of cuticular spines. The known species[1] include *A. sphaerula* (Looss, 1896) Faust, 1919; *A. nycteridis* Faust, 1919; *A. eptesici* Alicata, 1932; *A. molossidis* Martin, 1934; *A. oregonense* Macy, 1939; *A. ovatum* Yamaguti, 1939; *A. alicatai* Macy, 1940; *A. microcanthum* Macy, 1940; *A. pipistrelli* Macy, 1940; *A. jonesi* Sogandares-Bernal, 1956; *A. macyi* Sogandares-Bernal, 1956; *A. amphidymum* Cheng, 1957; *A. oligacanthum* Cheng, 1957; *A. sogandaresi* Coil and Kuntz, 1958; and *A. beuschleini* Cheng, 1959. *Mesothatrium japonicum* (Yamaguti, 1939) Sogandares-Bernal, 1956, a bat trematode of this subfamily known to possess posttesticular vitellaria and spines in the genital atrium, was considered a species of *Acanthatrium* by Cheng in 1957. Cheng revised the description of the genus *Acanthatrium* to definitely include forms having pre- or posttesticular vitellaria or both. In view of a parallel situation occurring in this subfamily between the genera, *Lecithodendrium* and *Prosthodendrium*, I agree with Sogandares-Bernal (1956) that the position of the vitellaria is of generic value and therefore *M. japonicum* should not be in the genus *Acanthatrium*. I propose that the genus *Mesothatrium* is valid and that the genus *Acanthatrium* be restricted to lecithodendriid trematodes having spined genital atria and pretesticular vitellaria.

In a recent parasite survey of bats from localities in Ohio and Kentucky, a new species of *Acanthatrium* was encountered. Fourteen specimens were found in seven of 51 big brown bats. The worms were first examined alive and then fixed in either 10 percent formalin or Lavdowsky's formula of AFA fixing reagent. Certain structures, such as cuticular spines and genitalia, could best be seen in living specimens. Final measurements were made from preserved and stained material mounted permanently in piccolyte or temporarily in glycerin.

Acanthatrium lunatum n. sp.

(Figures 1–4)

The name *lunatum*, from the Latin word "lunatus," refers to the crescent-shaped group of spines in the genital atrium, which character is distinctive for this species. The measurements appearing in parentheses in the following diagnosis are of the type specimen.

Diagnosis (based on 10 specimens).—Body pyriform to oval, 0.94–1.13 mm (0.96 mm) long by 0.36–0.55 mm (0.50 mm) wide. Minute cuticular spines covering either entire or anterior ¾ of body. Subterminal oral sucker comparatively large, 111–152 μ (152 μ) long by 118–146 μ (128 μ) wide. Pharynx muscular, 37–57 μ (47 μ) long by 39–64 μ (42 μ) wide. Esophagus in relaxed specimens attains length of 150 μ. Intestinal ceca of lecithodendriid type, 174–202 μ (187 μ) long by 37–59 μ (44 μ) wide. Acetabulum about same size as oral sucker, 112–151 μ (114 μ) long by 125–154 μ (154 μ) wide, located approximately midway in body. Testes lateral,

[1]Etges (1960, J. Parasitol. 46:235-240) describes a new species, *Acanthatrium anaplocami*, which is not included in this paper.

in same general transverse plane as acetabulum, slightly preacetabular or postacetabular depending on amount of body contraction. Right testis 99–171 μ (168 μ) long by 79–148 μ (148 μ) wide; left testis 111–172 μ (148 μ) long by 86–138 μ (112 μ) wide. Ovary oval, 91–142 μ (127 μ) long by 79–100 μ (90 μ) wide, on right side, dorsal, posterolateral to acetabulum, at an angle between right testis and acetabulum. Prostate mass large, 143–254 μ (149 μ) long by 143–222 μ (143 μ) wide, containing coiled seminal vesicle, numerous prostate cells, and anterior genital atrium lined with numerous long spines. Spines of genital atrium 15–28 μ (26 μ) long, 100 or more in number, arranged in a crescentic group in a brush-like fashion. Genital pore slightly posterior to atrial spines. Seminal receptacle and Laurer's canal present. Vitellaria pretesticular, bilateral, consisting of medium to large follicles, 10 to 15 per lateral group, anterior to testes but not extending mesad to esophagus. Uterus bulging with light brown eggs near metraterm. Eggs numerous, 25–30 μ (25–26 μ) long by 13–17 μ (14–17 μ) wide.

Host.—*Eptesicus fuscus fuscus* (Beauvois).

Site of infection.—Small intestine.

Locality.—Eleven specimens, including the type, from four bats taken in Columbus (Franklin County), Ohio. Three specimens from three hibernating bats taken in a cave at Carter Caves State Park (Carter County), Kentucky.

Type specimen.—Holotype and one paratype in U. S. National Museum Helminthological Collection, No. 38890. Other paratypes in The Ohio State University Helminthological Collection and in my collection.

This trematode has the arrangement of organs similar to *Acanthatrium pipistrelli* but differs from it primarily in the character of the atrial spines, the length of the esophagus, and the possession of cuticular spines. As indicated by Macy (1940), the slender atrial spines of *A. pipistrelli* are 25 μ long and number about 35; they are arranged in a compact slightly curved group. The atrial spines of *A. lunatum* are about three times as numerous and arranged in a broad crescentic group. The esophagus of *A. pipistrelli* is extremely short and there are no spines on the body surface; *A. lunatum* possesses a long esophagus and cuticular spines. The atrial spines of *A. eptesici*, another species closely resembling *A. lunatum*, are 25 μ long but arranged in a narrow compact group in the anterior part of the prostate mass rather than in a broad crescentic group as in *A. lunatum*. *A. eptesici* does not possess cuticular spines. *A. lunatum* differs from all other members of this genus mainly in the arrangement, size, and number of atrial spines.

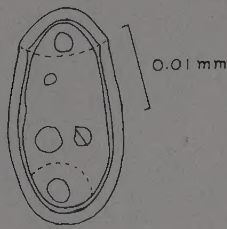
Key to the Species of the Genus Acanthatrium

1.	Esophagus present	2
1'.	Esophagus absent	15
2(1).	Cuticula spinose	3
2'.	Cuticula not spinose	6
3(2).	Atrial spines 15–28 μ long, 100 or more in number	*lunatum*
3'.	Atrial spines less than 15 μ long, less than 12 in number	4
4(3').	Atrial spines 7 in number, 7–8 μ long; eggs 28 μ x 14 μ	*macyi*
4'.	Atrial spines less than 7 μ long	5
5(4').	Atrial spines 11 in number, 3–5 μ long; eggs few, 31–50 μ x 10–28 μ	*beuschleini*
5'.	Atrial spines 9 in number, 2 μ long; eggs numerous, 27 μ x 19 μ	*oligacanthum*
6(2').	Ovary multi-lobed, in same transverse field as prostate mass	*sphaerula*
6'.	Ovary generally spherical or oval, not multi-lobed, posterolateral to prostate mass	7

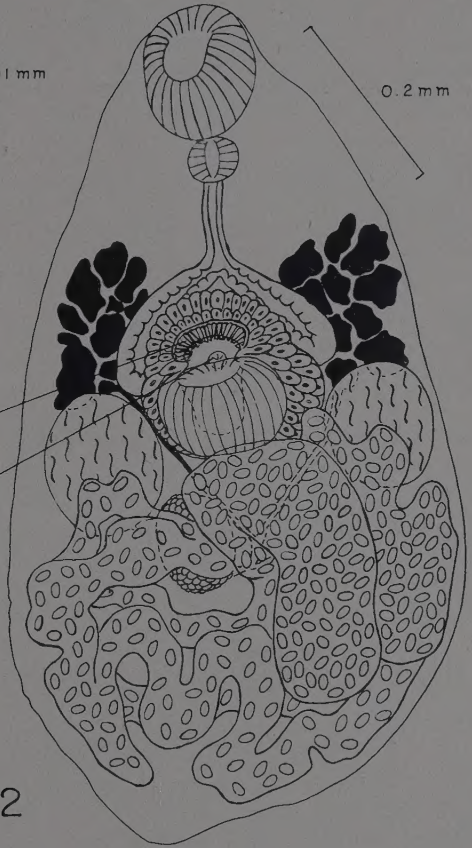
EXPLANATION OF FIGURES IN PLATE

1. *A. lunatum.* Egg.
2. *A. lunatum.* Ventral view of type specimen.
3. *A. lunatum.* Atrial spines of a paratype showing their brush-like arrangement.
4. *A. lunatum.* Atrial spines of type specimen.

AS—Atrial Spines.
GP—Genital Pore.



1



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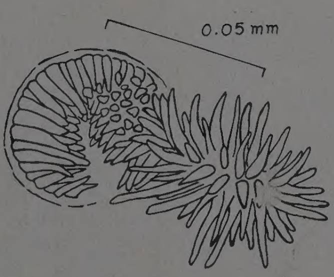

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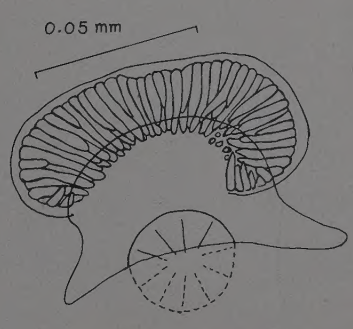

4

7(6'). Genital atrium divided into two or more chambers 8
7'. Genital atrium consisting of only a single chamber 10
8(7). Atrium divided into two chambers, atrial spines 14 μ long .... *amphidymum*
8'. Atrium divided into three chambers, atrial spines 10–26 μ long 9
9(8'). Atrial spines 10–15 μ long .... *nycteridis*
9'. Atrial spines 22–26 μ long .... *alicatai*
10(7'). Atrial spines 25 μ long 11
10'. Atrial spines less than 20 μ long 12
11(10). Atrial spines in single compact parallel group directed caudad; oral sucker larger than acetabulum .... *eptesici*
12(10'). Atrial spines circumferentially arranged; esophagus three or more times as long as pharynx .... *microcanthum*
12'. Atrial spines not circumferentially arranged; esophagus less than three times as long as pharynx 13
13(12'). Esophagus at least twice as long as pharynx; atrium with a conical diverticulum lined with spines 18 μ long .... *ovatum*
13'. Esophagus shorter than pharynx; atrium free of a diverticulum 14
14(13'). Oral sucker spherical or ellipsoidal, 0.070–0.077 mm wide; body length 0.46–0.65 mm .... *jonesi*
14'. Oral sucker not spherical or ellipsoidal, 0.11–0.16 mm wide; body length 0.70–0.81 mm .... *sogandaresi*
15(1'). Cuticula spinose, spines on anterior ⅓ of body; atrial spines 5 μ long, directed cephalad .... *molossidis*
15'. Cuticula aspinose; atrial spines 10–15 μ long, directed caudad .... *oregonense*

Acanthatrium nycteridis plicati Bhalerao, 1926, a subspecies, differs from *A. nycteridis nycteridis* mainly in the arrangement of the uterine coils, and the body, oral sucker, and acetabulum measurements being greater.

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BIOGENESIS OF ASPARAGINE FROM VARIOUS POSSIBLE PRECURSORS BY LENTIL SEEDLINGS[1]

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There are a number of possible pathways for the biogenesis of asparagine. Some of these are: (a) direct amidation of aspartate in the presence of ATP, in analogy of glutamine synthesis; (b) transamidation between aspartate and some amide; (c) amination of α-ketosuccinamate; (d) carboxylation of β-alanylamide, and (e) carbamylation of α-alanine. There is some evidence for or against the occurrence of several of these reactions. Thus, Webster and Varner (1955) found that extracts of wheat germ and of lupine catalyze the conversion of C^{14}-aspartate into asparagine in the presence of ATP and both ammonium and magnesium ions. Mardashev and Lestrovaya (1951) reported that liver extracts can form asparagine by transamidation between glutamine and aspartate. Similarly, Levintow (1957a, b) has observed that HeLa cells will incorporate the amide group of N^{15}-glutamine into asparagine, but will not incorporate the nitrogen of N^{15}-ammonia. In contrast, Webster and Varner (1955) were not able to find any evidence of a transamidation between glutamine and C^{14}-aspartate in extracts of wheat germ or lupine. The possibility of asparagine formation by amination of α-ketosuccinamate is raised by the demonstration of this reaction by Meister and Fraser (1954) but its biological significance is uncertain, because α-ketosuccinamate is not known to arise from sources other than asparagine itself. Finally, Webster and Varner (1955) could not demonstrate asparagine formation in wheat germ extracts by the carboxylation of β-alanylamide.

It is of considerable interest, therefore, to examine the formation of asparagine from various possible precursors by intact plant cells to determine whether evidence for or against any of the above pathways might be obtained. This paper reports on asparagine formation by lentil seedlings in the presence of various possible precursors.

METHODS AND MATERIALS

Lentil seeds were washed for 5 minutes in a 1 percent ethanol solution (by volume). They were then soaked for 30 minutes in water and planted in water-saturated vermiculite. Seedlings were grown for 5 days in the dark at 25° C. The seedling tissue was cut into 0.5-cm sections. These were shaken in the incubation medium at 38° C for the time periods indicated. After incubation, the tissue sections were washed thoroughly with distilled water and ground in a mortar with 1 ml of hot water. The extract was centrifuged at 5000 x *g* for 15 min. Amino acids and amides of the supernatant solution were separated by paper chromatography with Whatman No. 3MM filter paper and 90 percent aqueous phenol as the solvent. Duplicate chromatograms were prepared for each experiment. After a 24-hr development period at room temperature, the phenol was evaporated in a strong current of air. One chromatogram was sprayed with a 0.01 percent ninhydrin solution in acetone, and dried in an oven for 5 min at 65° C. Amino acids and amides were identified by R_F values and color. This chromatogram was used to help locate and identify radioactive areas on the second chromatogram. The distribution of radioactivity was determined initially with a Forro windowless chromatogram scanner and recording ratemeter; later with a Geiger-Muller tube and standard scaling circuit adapted for chromatogram

[1]Supported in part by a grant from the Graduate School of The Ohio State University.
[2]Predoctoral Fellow of the Republic of Iraq.

scanning. Location of radioactive amino acids and amides was confirmed by autoradiography with Eastman No-Screen X-ray film.

DL-aspartate-4-C^{14} and DL-alanine-1-C^{14} were obtained from the New England Nuclear Corporation. DL-glutamate-2-C^{14} was obtained from the Volk Radiochemical Company, and $C^{14}O_2$ was prepared from $BaC^{14}O_3$ obtained from the Oak Ridge National Laboratory.

RESULTS

Five-day-old lentil stems, roots, and cotyledons are able to incorporate aspartate-C^{14} into asparagine (table 1). Not only do stems absorb the greatest

TABLE 1

*Incorporation of asparate-C^{14} into the asparagine of lentil stems, roots and cotyledons**

System	Total radioactivity taken up by the cells (counts/min)	Total radioactivity incorporated into asparagine (counts/min)	Percent of absorbed activity incorporated into asparagine
Stems	6100.	1451.	23.8
Roots	5300.	975.	18.4
Cotyledons	3300.	363.	11.9

*One gm of tissue was incubated for 60 min at 38° C in 5 ml of a solution containing 0.075 M tris-(hydroxymethyl)-aminomethane-HCl (pH 7.0), 0.05 M L-aspartate, 0.04 M NH_4Cl, 0.04 M glucose and DL-aspartate-4-C^{14} containing a total activity of 228,500 counts per minute.

TABLE 2

*Incorporation of the carbons of various possible precursors into asparagine**

Substance	Percentage of absorbed radioactivity incorporated into asparagine	
	1-hour incubation	4-hour incubation
Aspartate-4-C^{14}	24.	19.
$C^{14}O_2$	10.	18.
Glutamate-2-C^{14}	11.	11.
Alanine-1-C^{14}	10.	8.

*Experimental conditions were the same as described with table 1.

quantities of aspartate into their cells, but they are also the most effective at the incorporation of aspartate into asparagine. Incorporation proceeds steadily for approximately 60 min, but further incubation (up to 240 min) results in little or no additional incorporation of aspartate into asparagine.

Aspartate is incorporated into asparagine more readily than any of the several possible precursors examined (table 2). The carbons of glutamate and alanine are incorporated only about half as effectively as aspartate; the carbon of CO_2 is incorporated more slowly, but more extensively, than the carbons of either glutamate or alanine. The fact that the carbon of CO_2 is incorporated into

asparagine over a 4-hr period indicates that the failure of aspartate to be incorporated into asparagine for longer than 60 min is not due to an inactivation of the tissue during the incubation period. Instead, some other factor must be either inactivated or consumed completely during the measured incorporation of aspartate into asparagine.

The relatively efficient incorporation of aspartate into asparagine may occur by the amidation of aspartate. It might be expected that $C^{14}O_2$ is incorporated by a carboxylation of either α-alanine or β-alanine, followed by the conversion of the aspartate thus produced into asparagine. The data of table 3 are not in

TABLE 3

Effect of D-*aspartate on the incorporation of aspartate-*C^{14} *and* $C^{14}O_2$ *into asparagine**

Precursor	Incubation time	
	1-hour	4-hours
Aspartate-4-C^{14}		
plus L-aspartate	23.8	19.2
plus D-aspartate	12.4	9.0
$C^{14}O_2$		
plus L-aspartate	11.7	18.5
plus D-aspartate	10.6	17.6

*Experimental conditions were the same as described with table 1, except that, where indicated, $NaHC^{14}O_3$ (total activity; 220,000 counts/min) was substituted for aspartate-C^{14}, and D-aspartate was substituted for L-aspartate.

TABLE 4

*Incorporation of the carbons of various possible precursors into glutamine**

Substance	Percentage of absorbed radioactivity incorporated into glutamine	
	1-hour incubation	4-hour incubation
Glutamate-2-C^{14}	40.	46.
$C^{14}O_2$	15.	18.
Aspartate-4-C^{14}	12.	10.
Alanine-1-C^{14}	6.	5.

*Experimental conditions were the same as described with table 1.

agreement with this thesis, however. While the presence of D-aspartate strongly inhibits the incorporation of aspartate-C^{14} into asparagine, D-aspartate hardly affects the incorporation of $C^{14}O_2$. If $C^{14}O_2$ were merely being incorporated into aspartate prior to its conversion to asparagine, one would expect the incorporation of $C^{14}O_2$ into asparagine to be inhibited also by D-aspartate.

The fact that glutamate is a less effective precursor of asparagine than aspartate is apparently not due to a block in the assimilation of glutamate. In contrast to its relatively poor utilization for asparagine synthesis, glutamate is utilized more effectively for glutamine synthesis than any other precursor examined (table 4).

Further evidence that aspartate is converted directly into asparagine is obtained from the degradation of asparagine with ninhydrin. Little radioactivity is found in the alpha carboxyl group of asparagine after the incorporation of aspartate-4-C^{14} (table 5). This suggests that aspartate is converted fairly directly into asparagine without extensive metabolism of the aspartate molecule (through the Krebs cycle, for example). In contrast, asparagine which has been formed in the presence of glutamate-2-C^{14}, alanine-1-C^{14}, or $C^{14}O_2$ contains about half of its radioactivity in the alpha carboxyl.

Likewise, glutamine which has been formed from glutamate-2-C^{14} contains little radioactivity in its alpha carboxyl, but contains much radioactivity if formed from aspartate-4-C^{14}, or from $C^{14}O_2$. These experiments agree with the data of tables 2 and 4 which show the preferential utilization of aspartate and glutamate for asparagine and glutamine syntheses respectively.

TABLE 5

Effect of ninhydrin treatment on the radioactivity of asparagine formed from various precursors

Precursor	Percentage of radioactivity lost by ninhydrin treatment	
	Asparagine	Glutamine
Aspartate-4-C^{14}	7.	47.
Glutamate-2-C^{14}	51.	5.
Alanine-1-C^{14}	54.	—
$C^{14}O_2$	44.	45.

*The reaction system was the same as described with table 1. Each precursor contained 1,000,000 counts per minute.

DISCUSSION

The data reported here are in agreement with the view that asparagine is formed from aspartate, and glutamine is formed from glutamate. The relatively poor incorporation of alanine, CO_2, and glutamate into asparagine suggests that the formation of asparagine by the carbamylation of alanine, the carboxylation of β-alanylamide, or the Krebs cycle conversion of glutamine (via α-ketoglutaramate, succinamate, etc.) to asparagine are either non-existent or quantitatively much less important than a direct conversion of aspartate to asparagine. These findings agree with those of Nelson and Krotkov (1956) that the pattern of labeling in broad bean leaves exposed to $C^{14}O_2$ is the same both in glutamate and glutamine and in aspartate and asparagine.

Increasing evidence that aspartate itself is a precursor of asparagine (in at least some organisms) raises a question as to the mechanism of the aspartate-asparagine conversion. The most likely mechanism for the conversion of aspartate to asparagine would seem to be either the direct amidation of aspartate with ammonia or a transamidation to aspartate from some amide. Evidence has been presented (Webster and Varner, 1955) for the occurrence in wheat germ and lupine of an enzyme system catalyzing a direct amidation of aspartate with ammonia in the presence of ATP. In contrast, no evidence has been found for asparagine formation by transamidation from glutamine to aspartate in lupine or wheat germ (ibid.), although evidence exists (Levintow, 1957a, b) for the occurrence of these reactions in animal cells. At present, the conversion of aspartate to asparagine measured in this investigation seems most probably to proceed by the direct reaction of aspartate and ammonia.

SUMMARY

Incorporation of the carbons of various possible precursors into asparagine and into glutamine in lentil seedlings has been measured. Glutamate carbon is most readily incorporated into glutamine and aspartate carbon is most readily incorporated into asparagine. Partial degradation of the formed glutamine and asparagine shows that glutamate and aspartate undergo little metabolism prior to their incorporation into glutamine and asparagine respectively. The incorporation of aspartate into asparagine is inhibited by D-aspartate, but the incorporation of CO_2 into asparagine is unaffected.

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This useful reference for stratigraphers and all geologists has been written by a man who understands the fundamental importance of stratigraphy to geology. He also realizes that stratigraphy and historical synthesis may lead one to error if the limitations of the working generalizations of stratigraphy are forgotten. This second qualification is especially important in the author of what will doubtless become an influential book.

No one can write such a book to satisfy all readers in every detail, but this book approaches that ideal. Thus, if slickolites are to be considered (p. 123), why not also the stratigraphically more important corrosion zones? The chapter on tectonics includes no reference to the work of Professor Carey. Such matters are overshadowed by the many excellent features. The time-transgressive nature of many formations is well set forth (p. 427–428). Significant examples of good and poor stratigraphic nomenclature are given (Ch. 13), as well as recommendations for rational usage. Correlation is similarly treated. We are reminded of the oft-forgotten limitations of paleogeographic maps (p. 589–593).

The work is very thorough, but is not just a catalog. For all phases of stratigraphy differing practices and interpretations are explained and judged, and preferred procedures are recommended. The book will probably serve best as a handbook for the apprentice or practicing stratigrapher and as a reference for advanced courses in stratigraphy.

MALCOLM P. WEISS

DICTIONARIES.

A number of dictionaries have come to the Review Editor during the past year and a half. The following list may be of interest to members of the Ohio Academy of Science:

Dictionary of Astronomy and Astronautics. *Armand Spitz* and *Frank Gaynor.* Philosophical Library. vi+439 pp. $6.00.

Aerospace Dictionary. *Frank Gaynor.* Philosophical Library. 260 pp. $6.00.

Dictionary of Atomic Terminology. *Lore Lettenmeyer.* Philosophical Library. 298 pp. $6.00.

A Short Dictionary of Mathematics. *C. H. McDowell.* Philosophical Library. xiii+63 pp. $2.75.

A Short Dictionary of Archaeology. *Christopher Trent.* Philosophical Library. 62 pp. $2.75.

Dictionary of Word Roots and Combining Forms. *Donald J. Borror.* N-P Publications. 134 pp. $2.00.

A Scientific Vocabulary for Students. *Mary J. Brown.* Pageant Press. 104 pp. $3.00.

THOMAS H. LANGLOIS

ARTHROPODS OF MEDICAL IMPORTANCE IN OHIO

CHARLES O. MASTERS
Sanitarian, Licking and Knox Counties, Ohio

It is rather difficult to state with authority that arthropods, which make up about 86 percent of the world's animal species, are not of medical importance in the state of Ohio. Public health workers know only too well that man is susceptible to many diseases, and when the causative organisms are present in an area inhabited by host animals and vectors as well as by man, troubles very often result. This was demonstrated very nicely in Aurora, Ohio, in 1934 when the causative organism of malaria was brought into that region. The other three necessary factors were already there (Hoyt and Worden, 1935).

When one considers that many centers of infection of some of the world's most serious human illnesses are now only hours away by plane, he can't help but wonder what the situation is in Ohio, relative to these other necessary factors. The opening of northern Ohio ports to foreign shipping also suggests the possibility of the introduction of unusual organisms. This is an approach to that particular aspect.

The phylum Arthropoda is divided into five classes of animals: Insecta, Crustacea, Chilopoda (centipedes), Diplopoda (millipedes), and Arachnida (spiders, scorpions, mites, and ticks). Representatives of these various groups which are found in Ohio and which might have some medical significance will be discussed.

There are nine species of mosquitoes breeding in the state of Ohio which are of medical interest. These are as follows: *Anopheles quadrimaculatus*, the vector of malaria in eastern United States, is not only common in weedy Ohio ponds but seems to be increasing in number. *A. punctipennis*, which is equally as abundant, is not a natural vector of the malaria parasite but adults have been infected in the laboratory. *Culex tarsalis* has been reported in Ohio by H. A. Crandell of the Toledo Area Sanitary District. It is the most important vector of both Western Equine and Eastern Equine Encephalitis in the United States. Other mosquito species have been incriminated, but *C. tarsalis* is the principal vector in the West.

Culiseta melanura seems to be rather rare in Ohio but it has been collected in central Ohio. It is a natural vector of Eastern Equine Encephalitis. *C. inornata*, on the other hand, is quite common in Ohio and is a serious pest. Specimens have been found to be naturally infected with the virus of Western Equine Encephalitis and it has been demonstrated that it can transmit the virus.

Other species of Ohio mosquitoes which are associated with the transmission of the various strains of Equine Encephalitis are *Culex pipiens* which is breeding in open dump areas in large numbers, *Mansonia perturbans* which is especially abundant in shaded areas close to water bodies containing much emergent vegetation, and *Aedes vexans* which is the worst pest species in the entire state.

Aedes triseriatus, a tree-hole breeder and a fierce biter, has been mentioned as a possible vector of Dengue. It is a major pest in some areas and is widely spread throughout the state.

At least five species of fleas of medical importance are found in Ohio. Two of these are commonly found on the Norway Rat, *Rattus norvegicus*. They are as follows: *Xenopsylla cheopis*, the Oriental Rat Flea, and *Nosopsyllus fasciatus*, the Northern Rat Flea. The Oriental Rat Flea is the principal vector of *Pasteurella pestis*, the bacillus which causes plague and *Rickettsia typhi* which causes murine typhus in man.

Pulex irritans, the human flea, too, is found in Ohio as it is elsewhere in the world. Since it feeds on other animals such as hogs and dogs as well as chipmunks and others, it is very often encountered on farms. Some infections of plague to humans may come about because of feces being deposited on the skin of man.

Ctenocephalides felis, the cat flea, and *C. canis*, the dog flea, are commonly distributed in

Ohio. They are the species usually implicated in the transmission of the tapeworm, *Dipylidium caninum*, from dogs or cats to children who accidently swallow the flea.

There are three species ot lice which are parasitic on man, *Pediculus humanus capitis*, the head louse, *Pediculus humanus humanus*, the body louse, and *Phthirus pubis*, the crab louse. All of these, of course, are found in Ohio. Only the body louse transmits the causative organisms of diseases as follows: louse-borne relapsing fever, trench fever, and murine strain of typhus, bubonic plague, and epidemic typhus.

Among the flies which are domestic to Ohio, many are capable ot, or actually do carry the organisms of disease. *Musca domestica*, the house fly, is the common carrier of *Shigella dysenteriae*, which produces bacillary dysentery in man. Its ability to transmit other organisms pathogenic to man is well known. Some of these are as follows: *Vibrio cholerae* which causes cholera, *Endamoeba histolytica* the producer of amoebic dysentery, and *Salmonella typhosa* the causative organism of typhoid fever.

Chrysops discalis, the deer fly, reported from Ohio is a proven carrier of tularemia to man.

Fannia spp., the lesser house fly, are of less importance as a disease vector than the house fly, but there are records of this genus producing myiasis in man and they are certainly capable of producing digestive disorders in man.

Stomxys calcitrans, the stable fly, is the "house fly that bites" in Ohio. It may easily be a mechanical transmitter of anthrax because of its habit of flying from animal to animal to feed. There may be some connection between this species and human conjunctivitis. The fly larvae, however, definitely do produce myiasis in man.

Muscina spp., false stable flies, are common in Ohio and transmit many of the organisms producing digestive disorders. Where there are cases of human intestinal myiasis, this particular genus is usually suspected. The flesh flies of the family Sarcophagidae are also capable of producing human intestinal myiasis.

Calliphoridae, the family of bottle and blow flies, certainly can not be overlooked. Usually they do not invade houses in Ohio, but in the fall in many rural areas they crawl through cracks of houses probably as a means of seeking shelter from the cold nights and eventually release themselves indoors. They are especially annoying to housewives because of their clumsy habits of flight and rest. There are reports of an existing connection between this group and polio but not too much is known. The larvae produce myiasis in man.

Oestridae, Cuterebridae, and Gasterophilidae are families of bot flies of some public health significance in Ohio as well as elsewhere. Myiases of various parts of the human body such as the eye, nasal passages, and frontal sinuses are caused by the larvae of these flies.

Chloropidae (Oscinidae), the eye flies, are very troublesome in parts of Ohio. Infectious materials may be easily transmitted from man to man by this fly. Hence it is a ready carrier of any organism causing conjunctivitis and possibly others.

Other flies which may be of lesser importance are as follows.

Family	Vectors of
Ceratopogonidae (Biting midges, punkies)	Human filariasis
Simulidae (Black flies)	Blinding filariasis, and tuleremia
Tabanidae (Deer flies, Horse flies)	Mechanical vectors of anthrax and tularemia.

Bees and wasps, because of their venomous stings, are certainly more than nuisances. Case histories ot persons having anaphylactic reactions are well known. As in all of the other states, Ohio is well populated with these insects.

Triatoma sanguisuga, of the subfamily Triatominae, are found mostly in parts of southern Ohio. They are known to harbor *Trypanosoma cruzi*, the causative organism of Chagas Disease. *Triatoma lecticularius*, another vector, is commonly found throughout the southern United States including all of Kentucky and might well be established in southern Ohio.

Cimex lectularius, the bed bug, has not been associated with the transmission of human diseases but occasionally causes severe bites to some people and contributes to nervous disorders.

Tenebrio molitor, the yellow mealworm, a common Ohio farm pest, has been known to carry *Hymenolepis diminuta*, the rat tapeworm, to man. It has also transmitted *Hymenolepis nana*, the dwarf tapeworm of the house mouse to man. Obviously, many of the enteric diseases of man can be transmitted by these insects.

Epicauta pennsylvanica, the "blister beetle" or "old fashioned potato bug" is common throughout the state. An oil known as cantharidin is contained within the bodies of the adults and will blister the skin of humans if the insects are crushed and rubbed into it.

Periplaneta americana, the American cockroach, is so very common it is sometimes not taken very seriously but it is definitely a carrier of the organisms causing dysentery, diarrhea, typhoid, and food-poisoning. They have also been found natuially infected with organisms of human polio. Other roaches which are almost as serious and found in Ohio are as follows: *Blattella germanica*, the German cockroach, *Supella supellectrilium*, the brown-banded cockroach, *Blatta orientalis*, the Oriental cockroach, and *Parcoblatta* spp., the wood roaches. Cockroaches are also known to carry *Hymenolepis diminuta*, the rat tapeworm, to man.

Among the arachnids there are many which are of public health importance. *Latrodectus mactans*, the black widow spider, has been repeatedly found in Ohio but is not too common. Actually, although extreme pain results from the bite of this spider, very few deaths have been reported.

Rhipicephalus sanguineus, the brown dog tick, is native to Ohio. It has been found to contain the toxin which produces tick paralysis in humans and easily transmits the various tick-borne typhuslike diseases. It is commonly associated with dogs and rarely bites man.

Amblyomma americanum, the lone star tick, is common over most of the state of Ohio. It is a transmitter of the spotted fever organism and other rickettsial disease agents as well as the bacillus *Pasteurella tularensis* which causes tularemia. Goats, sheep, dogs, and deer seem to be the principal hosts. Recently the tick has been shown to be the vector of *Coxiella burnetii*, a rickettsia which causes Q fever.

Dermacentor variabilis, the American dog tick, is commonly found throughout Ohio and is brought into homes by dogs. These are the primary transmitters of tularemia. They have also been shown to be carriers of the St. Louis strain of equine encephalitis. A disease with many of the clinical symptoms of dengue has been reported from New York with its causative organism, a virus, isolated from *D. variabilis*. The tick has also been shown to be responsible for tick paralysis and the transmission of *Rickettsia rickettsia*, the causative organism of spotted fever.

Laelops echidninus, the spiny rat mite, is found on the common Norway rat, *Rattus norvegicus*, and is suspected as being a carrier of tularemia.

Ornithonyssus sylviarum, the northern fowl mite, is common in Ohio chicken houses, and of course on chickens. It will bite man readily but never causes anything more serious than a rash.

Dermanyssus gallinae, the chicken mite, found in Ohio chicken houses in large numbers, bites humans causing a rash but nothing more.

Glyciphagus prunorum, the fruit mite, is commonly found on certain dried fruits such as raisins or prunes in grocery stores, and produces a rash known as "grocers itch" after biting.

Pyemotes ventricosus, the grain itch mite, found on infested straw in Ohio sometimes causes fever, intense itching, and secondary infections among humans coming in direct contact with the straw.

Sarcoptes scabiei, the itch mite, is found in Ohio and seems to be represented by many different forms. They are found on domestic animals and very often cause a short-lived case of mange in humans.

Allodermanyssus sanguineus, the house mouse mite, can be found living in association with the house mouse, *Mus musculus*, common throughout Ohio. The mite serves as a reservoir for *Rickettsia akari*, the causative organism of rickettsialpox in humans.

Trombicula spp., the common chiggers, are a pest in many places in Ohio usually biting the ankles, areas of the waistline, and armpits. In America they are not known to carry diseases but in Asia they are important vectors of the causative organisms of scrub typhus. Obviously, much work has to be done with the mites in order to learn their true public health significance.

I wish to thank the members of the staff of the Insect and Rodent Control Training Branch, Communicable Disease Center, U. S. Public Health Service, Atlanta, Georgia, for their very kind and valuable assistance.

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RELATIVE DAILY ABUNDANCE OF PLANKTONIC CRUSTACEA IN THE ISLAND REGION OF WESTERN LAKE ERIE*

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INTRODUCTION

The abundance and distribution of plankton crustacea in western Lake Erie has been discussed by several investigators in the past thirty years. Wright and Tidd (1933) found, "The crustacea were not uniformly distributed in the Island Section, but there was no evidence that they were consistantly abundant at certain stations and consistantly rare in others." Chandler (1939) showed great fluctuations in the abundance of plankton at specific localities throughout the year. Jahoda (1949) studied only the genus *Diaptomus* in an area overlapping that of the other investigators. In all cases the sampling by these workers was done at weekly or, in some cases, longer intervals. None considered in detail daily fluctuations.

Many recent limnological studies have emphasized the role of plankton in the productivity of natural bodies of water. This approach has resulted in concern with the bulk of various components of the plankton but overlooks numerical relationships between component groups and short term fluctuations in abundance of certain important species.

Damage to fish fry by cyclopoid copepods was reported by Davis (1959). The role of cyclopoids as predators of fry has been further evaluated by Fabian (1960). In view of the possible importance of population densities of carnivorous species in specific localities during certain critical periods, it seemed advisable to have some basis for comparing herbivore-carnivore plankton populations and evaluating the accuracy of sampling at weekly intervals.

METHODS

The period covered by this study was from June 30, to August 21, 1959. A single collection station was selected between Gibraltar and Middle Bass Islands which was considered to represent open water conditions of the island region. The station was located about one fourth of a mile west of the northeast end of Gibraltar Island at the intersection of ranges formed by the sign on the Cities Service fuel pier on South Bass Island and the tip of Gibraltar, and by the Middle Bass Island water tower and the number 2 bell buoy at the entrance to Put-In-Bay harbor.

Plankton was collected with the Juday Plankton Trap. Ten-liter samples were taken daily at three different depths. The depths of these samples were 0 meters (surface), 5 meters below the surface, and at the bottom. Due to oscillations in the lake, the depth at which the bottom sample was taken varied from day to day about an estimated mean of seven and one-half meters (Krecker, 1928). Regardless of lake level this sample was taken about one foot above the bottom.

The plankton concentrate was emptied from the bucket of the trap and immediately fixed in five percent formalin. The sample was taken back to the laboratory where distilled water was added to adjust the volume of concentrate to 25 ml. When a count was to be made, the organisms were shaken into suspension each time that an aliquot was drawn off. Five 1-ml aliquots were drawn off with a wide mouth volumetric pipette and delivered to the counting chamber.

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*This study was carried out at the Franz Theodore Stone Laboratory, Put-In-Bay, Ohio.

A total differential count was then made of the crustacea present (see Welch, 1948).

Two groups of crustacea are dominant in the open water plankton of western Lake Erie. These are the Copepoda and the Cladocera. Other crustecea, namely Amphipoda and Ostracoda, occur in such small numbers that they may be considered insignificant. (These occured in concentrations far less than one organism per ten liters of water in the open lake.) Both carnivorous and herbivorours species of copepods and Cladocera are known. This differentiation seemed to be an appropriate one in view of possible support of the above mentioned investigations (Davis, 1959; Fabian, 1960). Accordingly, four categories of crustacea were considered in this study: calanoid copepods, cyclopoid copepods, Cladocera other than *Leptodora*, and *Leptodora*. The basis for these distinctions will be discussed later. Nauplii of copepods were not included in the tabulations, but both adult and copepodid stages were counted. Data from three different levels were added and means of each category were determined to give an average number per unit volume throughout the column (see table 1).

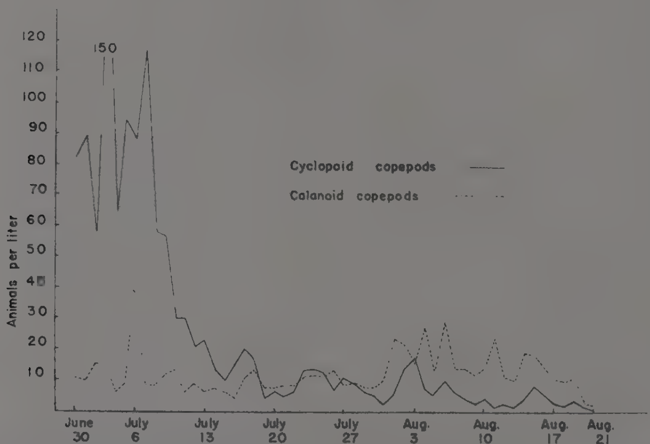

FIGURE 1. The daily population densities of cyclopoid and calanoid copepods collected at the same location daily in the Bass Island region of Lake Erie in 1959.

RESULTS

In past studies of Lake Erie, copepods have been categorized in different ways. Chandler (1939), while discussing copepods on the species level, summarized his quantitative data under one broad heading of "Copepods." Collection data were tabulated as "Cyclops" and "Diaptomus" by Wright and Tidd (1933) who recognized these as "dominant genera." It is assumed that "Cyclops" (also see Birge and Juday, 1912) includes other cyclopoid genera and that "Diaptomus" was used as a categorization of all calanoid genera.

There is a sound basis for such a division but the proper designation should be given to the groups. The two suborders of limnetic copepods are generally quite distinct in their feeding habits. The Calanoida, represented in Lake Erie by *Diaptomus*, *Limnocalanus*, and *Epischura*, are filter feeders which graze on small phytoplankters and debris (Marshall and Orr, 1955). The Cyclopoida are represented by several species of *Cyclops* and *Mesocyclops* which are particulate

TABLE 1

*Average daily populations of plankton crustacea in Lake Erie during the summer of 1959**

Date	Calanoida	Cyclopoida	*Leptodora*	Other Cladocera
June				
30	11.1	82.3	0	13.1
July				
1	10.2	89.4	0	9.0
2	15.5	58.3	1.0	24.2
3	15.1	150.3	1.8	17.1
4	6.0	66.5	0.2	24.2
5	9.0	94.4	1.5	49.1
6	41.2	88.0	0.2	120.5
7	8.5	117.4	2.1	18.1
8	8.3	58.3	0.8	59.5
9	12.2	57.0	19.3	183.0
10	13.4	30.2	1.5	63.3
11	6.0	30.4	2.6	34.3
12	9.3	21.1	2.0	37.1
13	6.0	23.3	1.1	24.4
14	7.2	13.3	1.2	27.1
15	6.3	10.6	0.2	10.1
16	4.0	15.3	0	30.2
17	11.3	20.0	1.0	25.1
18	13.4	17.4	0.2	19.3
19	7.4	4.4	1.3	29.3
20	7.5	6.5	1.5	92.0
21	8.3	4.9	0.8	23.6
22	8.3	6.0	0.5	11.8
23	11.3	8.7	0.7	11.3
24	11.7	9.1	2.0	16.3
25	11.3	8.0	2.0	25.5
26	13.2	6.8	0.3	21.5
27	8.6	11.2	0.5	11.0
28	9.0	9.0	0.2	18.8
29	7.8	6.3	0.7	23.2
30	7.8	5.3	0.2	6.5
31	10.3	2.7	0	11.0
August				
1	23.7	5.5	1.3	9.0
2	21.2	9.0	0.2	25.7
3	15.8	12.8	1.3	25.7
4	27.3	7.3	0.5	30.8
5	13.0	5.7	0.2	28.3
6	29.5	10.3	0.5	71.3
7	13.7	6.3	0.2	34.7
8	14.0	4.0	0.3	45.8
9	11.5	2.7	0.3	40.8
10	13.8	4.8	1.0	27.2
11	23.8	1.5	0.5	56.0
12	11.2	2.8	0	52.5
13	10.0	1.2	0.2	41.3
14	19.2	4.0	0	66.5
15	18.3	8.5	1.3	118.7
16	No sample			
17	10.3	2.7	0.1	69.0
18	9.8	1.8	0	32.3
19	10.8	3.3	0.3	71.2
20	2.3	1.2	0.2	11.0
21	2.0	0.5	0.2	6.0

*Animals per liter, exclusive of copepod nauplii.

feeders of omnivorous habit. The suborder designation has been followed in this paper.

Among the Cladocera, *Leptodora* (one species, *L. kindtii*) is sufficiently distinct to draw attention wherever it is found. Since it is a carnivore, it is listed separately from other cladocera. *Leptodora* was not found in the large numbers implied by Andrews (1949). The largest group of cladocera was of the genus *Daphnia*, but *Bosmina*, *Chydorus*, and *Diaphanosoma* showed periodic pulsations during the summer.

I found that cyclopoid copepods exhibited a pulse in early July (average density of about 90 per liter). The population then dropped to a low in mid-July and remained at a near level of less than 15 per liter for the rest of the survey (fig. 1).

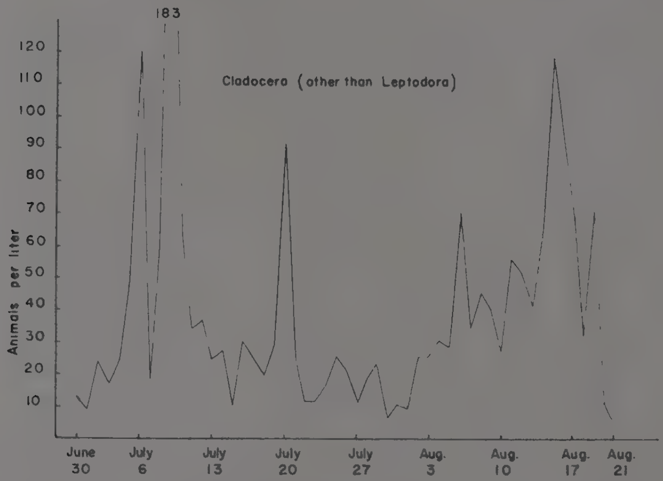

FIGURE 2. Daily population densities of Cladocera other than *Leptodora*.

The population of calanoid copepods reached a maximum in early July and another in early August, but otherwise was very stable (fig. 1). The daily figures, when examined for seasonal trends, demonstrate a change in copepod population during the summer. This was a progressive shift from a predominantly carnivorous (Cyclopoida) to a largely herbivorous (Calanoida) population (fig. 1).

Cladocera (other than *Leptodora*) showed a sizable population surge in early July (one day's average was over 180 per liter). A substantial but smaller pulse was evident in early August. Cladocera showed tremendous day to day fluctuations suggestive of the "swarms" of early authors (Needham and Lloyd, 1916). While the day's average density on July 9 was 183 cladocera per liter, it should be stated that the surface density was 447 animals per liter! The following day the cladoceran population at the same location was 63 animals per liter. These figures indicate the possible errors inherent in taking plankton samples at weekly intervals. A striking illustration of this point can be made by considering the conclusions that might have been reached from a series of weekly collections of Cladocera begun on June 30, contrasted to weekly collections begun one day later, on July 1 (fig. 3).

Leptodora exhibited little in the way of population change during the summer. Numbers of this animal were too low to permit plotting them on a scale comparable to that of other cladocera. Qualitative collections made at night near the surface might lead one to believe that much larger populations are present, an assumption not borne out by the present quantitative data.

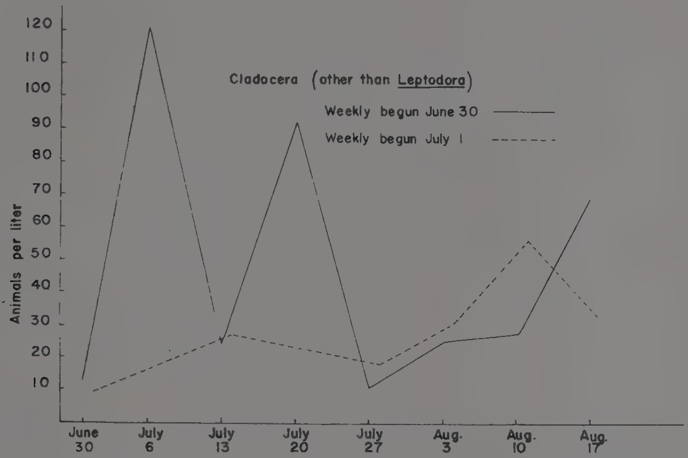

FIGURE 3. The interpretation resulting when data included in figure 2 are plotted at weekly intervals. The solid line connects points representing a series of collections begun on June 30. The broken line represents a similiar series begun one day later, on July 1, 1959.

SUMMARY

1. Planktonic crustacea populations showed great variation when sampled daily at the same location with the Juday Plankton Trap.
2. During the summer there was a progressive shift in the copepod population from predominantly carnivorous (Cyclopoida) to one of largely herbivorous (Calanoida) components.
3. Both copepod and cladoceran populations exhibited blooms in early July followed by low densities in late July.
4. Cladocera (other than *Leptodora*) showed the most daily variation in numbers during the period studied.
5. Quantitative data presented indicate the possible errors inherent in taking plankton samples at weekly intervals.
6. *Leptodora kindtii* was found to occur in very low densities in the open water of the Bass Island region of Lake Erie.

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Mathematical Tables and Formulae. *F. J. Camm*, Compiler. Philosophical Library, Inc., New York. 1958. 144 pages. $2.75.

This sixth edition of Camm's pocket-size tables has permitted him "to revise the text and to correct minor printers' errors." In addition to the tables, both an index and a table of contents are included.

D. McConnell

In view of the widespread interest in recent developments in Africa, the following books are considered timely for presentation to the members of The Ohio Academy of Science.

Algeria: the realities. *Germaine Tillion*. Alfred A. Knopf Co. 115 pp. $2.50. Translated from the French by Ronald Matthews.

The authoress is a sociologist and teacher at the Sorbonne University. She presents with great clarity the problems confronting the ½ of the human race who "have," and the others who "have not." It describes the pauperization by largesse of those members of the latter group who have existed by and perpetuated archaic cultures, and it categorizes such pauperization as the crime of the century.

The Foreign Policy of the United States in Liberia. *Raymond W. Bixler*. Pageant Press. 143 pp.

The author is Professor of History at Ashland College, Ashland, Ohio. By searching documents, extensively and intensively, he has found how American foreign policy has contributed to the creation and maintenance of this small nation, Liberia, in Africa, and his account is fascinating. The story carries through World War II, and shows how Liberia, with Firestone aid, has developed a huge rubber industry. Scholarliness is attested by a bibliography which includes the documentary sources, books, periodicals and newspapers, then a chapter by chapter list of references.

The Open Door on the Old Barbary Coast. *Raymond W. Bixler*. Pageant Press. 1959. 204 pp. $3.50.

This book tells about the establishment and pursuit of the policy of the open door on the south shores of the Mediterranean. The references consulted (all carefully cited and listed) were found mainly in the National Archives and in the Cleveland Public Library. The peoples of the Old Barbary States early attained independence from the Ottoman Empire, but were largely Moslem, and they were bound together by a tradition of centuries of strife with Christian Europe. The United States established the open door policy, a policy which came to be challenged by the invasion and exploitation of North Africa by certain strong European states. The door was re-opened after World War II, and now the whole area is in turmoil, while new African states are being formed throughout much of the rest of that continent.

Cultures and Societies of Africa. *Simon and Phoebe Ottenberg*, Editors and Contributors. 1960. Random House. 614 pp. $7.50.

The editors introduce this collection of readings in Anthropology with a long description of the geography of Africa, of the physical types of peoples living there, of their languages, histories, social and political organizations, and of their art and folklore. These topics are amplified by a wisely selected series of reprints of original studies which are grouped under the headings of People and environment, Social groupings, Authority and government, Values, Religion and Aesthetics, Culture contact and change.

This book aims to provide some background of facts about African cultures so there might be better understanding of changes now taking place. It records some facts which might become lost in the near future.

Thomas H. Langlois

ADDITIONAL NOTES ON THE ODONATA (DRAGONFLIES) OF OHIO

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Since 1941 I have collected dragonflies at odd moments. This paper lists the distribution and other observations recorded for the Odonata of Ohio. The majority of my records are from Ashland County; other records of interest are also presented at this time.

Certain collecting sites in Ashland County may be mentioned because of the dragonfly fauna found in the area. The Savannah Lakes in Clear Creek Township are glacial potholes. *Enallagma ebrium* and *Gomphus spicatus* are distinctive of these. A series of similar potholes lies in Lake Township, and one of these, Round Lake, has been visited repeatedly. The dragonflies collected at Round Lake include *Celithemis monomelaena*, *Aeschna mutata*, *Libellula incesta*, *Lestes inaequalis*, *L. vigilax*, and *Enallagma traviatum*. Perhaps the most varied dragonfly fauna of Ashland County is found along the Mohican River from the Pleasant Hill Dam in Hanover Township to the Holmes County line. This fauna is particularly rich in gomphines, but includes other types. Two flood-control reservoirs of the Muskingum Conservancy District, namely, the Pleasant Hill Reservoir and the Charles Mill Reservoir touch Ashland County, but neither has produced a rich or distinctive dragonfly fauna. In addition dragonflies were collected at numerous places in streams, ponds, and swamps.

I have taken 80 species in Ashland County, but I have not recaptured 3 species recorded by Borror (1937). These are *Hagenius brevistylus* from the Ohio State University Collection, *Gomphus abbreviatus* taken by Hine in 1900 and 1913, and *Agrion angustipenne* also from the Ohio State University Collection. The total species recorded for Ashland County are now 83.

Other collecting sites of possible interest have been visited. Sites Lake in Mifflin Township of Richland County is a glacial pothole and produces *Gomphus spicatus*, *Lestes inequalis*, and *Enallagma traviatum* as well as other species encountered in various habitats. The Leesville Reservoir in Carroll County and the Tappan Reservoir in Harrison County were each visited once, as well as the creek and millpond at Phalanx Mills, Trumbull County. Brown's Lake Bog in Wayne County produces many of the dainty damsel fly, *Nehalennia gracilis*.

LIST OF SPECIES

The species in the following list are numbered according to Borror's (1937) list. The records are given by counties, and other observations deemed worthy of reporting are included.

4. *Ophiogomphus rupinsulensis* (Walsh). Coshocton, Knox.
9. *Gomphus exilis* Selys. Carroll. This record is based on one specimen taken by Mr. Jon Shidler and presented to me.
10. *Gomphus fraternus* (Say). Richland.
12. *Gomphus graslinellus* Walsh. Ashland, Richland.
13. *Gomphus lineatifrons* Calvert. I have taken 2 females of this large rare gomphine; a specimen taken June 23, 1943, extends the extreme date of late occurrence in Ohio.
18. *Gomphus spicatus* Hagen. Richland.
19. *Gomphus spiniceps* (Walsh). Ashland.
22. *Gomphus villosipes* Selys. Ashland. Collected as late as July 5, 1945.
23. *Gomphus viridifrons* Hine occurs along the Mohican River as late as June 23 (1943).
24. *Dromogomphus spinosus* Selys. Ashland.

26. *Lanthus albistylus* Hagen. On June 7, 1959, Mrs. Harwood observed the transformation of this species on a stone at the edge of the Mohican River near Ball Run. I captured specimens on July 28, 1959. These records extend the season of flight of this species in Ohio.
28. *Basiaeschna janata* (Say). Ashland.
30. *Boyeria vinosa* (Say). Ashland, Holmes.
31. *Anax junius* (Drury). Trumbull.
34. *Epiaeschna heros* (Fabricius). Ashland.
36. *Aeschna constricta* Say. Ashland, Richland. Taken as early as July 16, 1945.
37. *Aeschna mutata* Hagen. Ashland.
38. *Aeschna umbrosa* Walker. Ashland, Ashtabula, Richland. The latest date of capture is November 1, 1947, when this species was observed feeding on flying aphis.
39. *Aeschna verticalis* Hagen. Ashland.
40. *Cordulegaster diastatops* (Selys). Ashland.
43. *Cordulegaster obliquus* (Say). Ashland.
44. *Macromia illinoiensis* Walsh. Ashland.
49. *Epicordulia princeps* Hagen. Carroll, Richland.
50. *Tetragoneuria cynosura* (Say). Carroll, Huron.
133. *Somatochlora linearis* (Hagen). Ashland, Lorain. July 25, 1954, to September 3, 1950. On July 25, 1954, I observed a female ovipositing in the shade on moist gravel in Findlay State Park. She was wary and difficult to approach closely. When disturbed she flew into the sunshine, but returned to the side of the same shady pool in a few minutes. By moving very slowly, I was able to capture her.
52. *Somatochlora tenebrosa* Say. Ashland.
54. *Perithemis tenera* (Say). Carroll, Harrison, Trumbull.
56. *Celithemis eponina* Drury. Harrison.
57. *Celithemis monomelaena* Williamson. Teneral specimens of this insect were observed at Round Lake, Ashland County on June 11, 1950.
63. *Libellula incesta* Hagen. Ashland, Holmes, Wayne. This species has never been seen at the Savannah Lakes, but it is abundant at Round Lake and Long Lake in southern Ashland County. It has been taken from June 24, 1950, to August 15, 1959.
66. *Libellula pulchella* Drury. Carroll.
67. *Libellula quadrimaculata* Linnaeus. Ashland.
68. *Libellula semifasciata* Burmeister. Ashland.
69. *Libellula vibrans* Fabricius. Ashland. This species was found about woodland pools in extreme northern Ashland County from June 14 to July 4, 1959. The area is rich in limestone. Since *L. vibrans* has not been found about numerous woodland pools that have been visited in the acid-soil areas of Ashland County, it seems possible that *L. vibrans* prefers calcareous soils.
65. *Plathemis lydia* Drury. Stark, Trumbull.
72. *Sympetrum obtrusum* (Hagen). Ashland.
74. *Sympetrum semicinctum* (Say). Ashland.
76. *Sympetrum vicinum* (Hagen). Ashland, Clark.
77. *Leucorrhinia intacta* Hagen. Ashland.
78. *Pachydiplax longipennis* (Burmeister). Clinton.
79. *Erythemis simplicicollis* (Say). Carroll, Trumbull. In 1947, this species was taken as early as May 4.
80. *Pantala flavescens* (Fabricius). Ashland.
81. *Pantala hymenaea* (Say). Ashland. This species and its congener appeared in numbers in Ashland County from August 12 to September 2, 1956. I have not seen either species in other years.
87. *Agrion maculatum* Beauvois. Carroll.
91. *Lestes congener* Hagen. Ashland, Holmes. The flight season of this species extends from June 26, 1959 to October 28, 1959 according to my collection records.

On September 13, 1959, I found several pairs of this species ovipositing on the borders

of a woodland pond in Montgomery Township of Ashland County. Color photographs were taken and the act of oviposition observed under a 14X hand lens. Samples of leaves containing eggs were brought to the laboratory and dissected under a stereoscopic microscope. Since these several observations are sometimes at variance with recorded observations, they may possibly be worth reporting.

The pond was surrounded by trees. Consequently, the margins were sparsely lined with herbacous plants, such as *Bidens*, *Iris*, *Leersia* and *Glyceria*. The *Lestes congener* were perched on all the plants, but the limitation of tandem pairs to clumps of *Glyceria* sp. first attracted attention. When disturbed these pairs alighted on all nearby objects, including the trunks of trees. Females were observed probing all surfaces with their ovipositors, but were observed to complete the act only in dead leaves and sheaths of *Glyceria*. When driven from the clumps of this grass, the tandem pairs returned to the same clump or another of the same species in a few minutes. Although they lighted on living plants of *Glyceria*, oviposition was limited as indicated. This is contrary to Walker (1953) who reported *L. congener* ovipositing both in green and in dead vegetation.

The position while ovipositing is exactly as figured by Walker (1953). The female's head, thorax, and first three abdominal segments are nearly at right angles to the supporting surface. A sharp bend brings the fourth segment nearly paralled to the surface. The remaining segments descend directly to the leaf.

The act of ovipositing as observed under a hand lens was described as follows in my notebook. "The female arches her abdomen as Walker describes, the terebra is unsheathed and thrust into the dead grass leaf by a series of muscular contractions involving the entire abdomen. I did not count the muscular jerks but estimate that 100 require less than a minute. The terebra is thrust into the leaf until the valves of the sheath are flat against the surface. The abdomen is at this time bent sharply between segments 7 and 8."

The eggs were laid from 3 to 18 in. above the surface of the earth. Water, which was fully covered by duckweed, was about 6 ft from the base of the plants used for oviposition. I ascertained by dissection of marked sites that the terebra may be inserted and withdrawn without oviposition taking place.

The eggs were dark brown, about 2 mm long and about ⅕ as wide. They were nearly cylindrical, rounded at one end and pointed at the other. They were laid in a single row; not in two parallel rows as figured and described for several European species of *Lestes* by Schiemenz (1957). The distance between eggs in a row varied from 2 to 5 mm. The long diameter of the egg was often in line with the row, or it lay at an angle of as much as 30°. The diameter of the eggs was greater than the space between upper and lower epidermis. Therefore, the leaf surface bulged slightly over each egg.

92. *Lestes disjunctus australis* Walker. Ashland.
94. *Lestes forcipatus* Rambur. Ashland, Huron, Richland.
95. *Lestes inaequalis* Walsh. Richland, Wayne. My earliest collection date, June 11, 1949, from Round Lake advances the flight season for Ohio slightly.
96. *Lestes rectangularis* Say. Price (1958) writes that specimens taken late in the season at Dehn's Swamp in Williams County were the smallest he has seen. I took specimens of average size at the Goose Pond in Ashland and Wayne Counties on October 28, 1950, which is the latest seasonal date recorded for Ohio.
97. *Lestes dryas* Kirby. Huron. Taken as late as August 16, 1959, in Ashland County.
98. *Lestes unguiculatus* Hagen. Ashland.
99. *Lestes vigilax* Hagen. Ashland. I collected this species only once, August 24, 1947, at Round Lake. This extends the flight-season for Ohio by 3 weeks.
100. *Argia apicalis* (Say). Ashland, Holmes, Richland, Trumbull.
102. *Argia moesta* (Hagen). Lorain, Richland. In 1949, this species was especially abundant along the Mohican River in Ashland County. On September 10, 1949, females, attended in every case by males, were observed ovipositing in leaves of the sycamore (*Platanus occidentalis* L.). The river was low and the large yellow leaves that were dropping in some numbers lodged frequently against stones that barely protruded above the surface of the water. These leaves were favored sites for oviposition and as many as 16 pairs were

observed perched on a single leaf. The sycamore leaves were the most favored sites for oviposition, but not the only site employed.

103. *Argia sedula* (Hagen). Ashland. Taken as late in the season as September 22, 1947, in Ashland County.
104. *Argia tibialis* (Rambur). Huron.
105. *Argia violacea* (Hagen). Belmont, Carroll, Guernsey.
106. *Amphiagrion saucium* (Burmeister). Ashland, Morrow, Richland.
107. *Nehalennia gracilis* Morse. Wayne.
109. *Chromagrion conditum* (Hagen). Morrow.
110. *Enallagma antennatum* (Say). Ashland, Lorain, Richland.
111. *Enallagma aspersum* (Hagen). Ashland, Belmont, Crawford, Madison, Morrow, Richland. A collection record of September 10, 1950, extends the flight season of *E. aspersum* by a month
129. *Enallagma basidens* Calvert. Ashland.
113. *Enallagma carunculatum* Morse. Harrison.
114. *Enallagma civile* (Hagen). Ashland, Trumbull.
115. *Enallagma divagans* Selys. Ashland, Richland.
117. *Enallagma ebrium* (Hagen). Ashland.
118. *Enallagma exsulans* (Hagen). Ashland.
119. *Enallagma geminatum* Kellicott. Carroll, Richland, Trumbull, Wayne.
120. *Enallagma hagani* Walsh was taken as late as July 15, 1948.
121. *Enallagma signatum* (Hagen). Trumbull.
122. *Enallagma traviatum* (Selys). Ashland, Carroll, Richland, Wayne.
123. *Enallagma vesperum* Calvert. Richland. Taken as late in the season as September 18, 1941.
124. *Ischnura posita* (Hagen). Richland.
127. *Anomalagrion hastatum* (Say). Ashland, Wayne. Taken on October 28, 1950, at the Goose Pond in Wayne County. This record extends the known flight season for Ohio by more than a month.

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The Ecology of Invasions. *Charles S. Elton.* John Wiley & Sons. 181 pp. $5.25.

This book, written by the author of the first good textbook of animal ecology, brings together the facts of faunal history, the ecological concepts of the structure and dynamics of populations, and the theme of conservation. With this multiple viewpoint, there are detailed discussions of invasions (natural and man-caused) of continents, islands, fresh-waters, and seas, by all suitable groups of organisms. His conclusions are that there is need for actually planning a better and more varied landscape so as to put into the altered landscape some of the ecological features of wilderness, phrasing it as follows:

"From now on, it is vital that everyone who feels inclined to change or cut away or drain or spray or plant any strip or corner of the land should ask themselves three questions: what animals and plants live in it, what beauty and interest may be lost, and what extra risk changing it will add to the accumulating instability of communities. That is: refuge, beauty and interest, and security."

In its 174 pages there are references to 297 publications. This list alone is worth while, and the entire text is stimulating.

THOMAS H. LANGLOIS

ASTRONOMICAL OBSERVATIONS BY MEANS OF HIGHLY SENSITIVE ELECTRONIC LIGHT AMPLIFICATION

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AND
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Several different systems have been devised and used for observing and recording the image or information produced by a telescope. Many investigators have employed a photomultiplier tube. Hunten (1953) made use of one in the study of the aurora. Gehrels (1959) used one in the study of the polarization of the light of the moon and planets. Other investigators have made use of the photoelectric cell with suitable amplification. Stebbins of the United States (1910) and Guthnick of Germany (1913) were pioneers in developing this instrument for the study of variable stars. With a spectroscopic analysis and using a lead selenide cell, Sinton (1957, 1959) found evidence of vegetation on Mars. Oke (1957) has developed a new photoelectric spectrometer that measures light variation in 21 different wavelengths between 3400 and 5200 Angstroms. Hall (1958) and his coworkers (1959) have intensified the faint photographic image by various means. Electron image-converters have been developed in both the U.S.S.R. and the United States. Hiltner and his associates (1955) have worked in this field in the United States. An electronic camera that has proven very satisfactory has been developed by Lallemand of the Paris Observatory (1936, 1958). The use of closed circuit television arrangements has been investigated by McGee (1955) and Felgett (1955). Different fields of investigation require different systems. This paper will treat only electronic devices that do not employ mechanical scanning. Improvements that make possible very sensitive closed circuit television systems for astronomical observations will be described. The work was performed under a research program sponsored by the United States Air Force under the guidance of Gebel, who is one of the authors. The astronomical observations were made at Wittenberg University in cooperation with Wylie, who is another one of the authors.

The exposure time needed for astronomical observations may be decreased in a simple way by the use of the image-converter tube. The image is focused on the photocathode of the image-converter and the emitted electrons constitute an electron image. Intensification is accomplished by giving these electrons a high level of energy by accelerating them in an electric field. The intensified visible image, which can be observed or photographed, is produced by the impact of these electrons on a phosphor screen. If one only wants a photographic record, the phosphor screen may be replaced by an electron-sensitive plate. This is the electronic camera of Lallemand (1936, 1958). Recent models of this camera have several photographic plates on a revolving drum that is inside the vacuum of the tube, but which can be manipulated from outside the vacuum. The exposed plates can only be recovered by opening the tube. A photographic speed, that is better than one hundred times as great as that obtainable with photographic plates ordinarily used, is achieved by this system, and it has a resolution that is better than two hundred lines per millimeter.

The phosphor screen and glass on which the screen is placed may be replaced by a very thin metal foil, known as a Lenard window. The Lenard window permits electrons to pass out of the vacuum of the tube. The electron-sensitive

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plate is pressed directly against the Lenard window, and therefore a large number of plates may be exposed without breaking the tube (Pauli, 1910; Coolidge, 1926; Vollrath, 1931; Von Boris, 1932). The results obtained with the Lenard window are not as good, so far, as those obtained with the electronic camera of Lallemand.

Intensifier screens, consisting of a thin layer of phosphor followed by a thin photocathode, may be used to produce an image-converter of two or more cascaded stages (Morton, Ruedy, Krieger, 1948). When several cascaded stages are used to attain high sensitivity, or to produce high amplification so that short exposure times can be utilized, resolution is seriously impaired. Furthermore, the dark current of an uncooled photocathode will appear as an additional background illumination on the phosphor viewing screen. This places a definite limit on the usefulness of the image-converter tube when photographing faint stars. For good identification, with photographic emulsions normally used in astronomical work, the star should provide at least one-sixth to one-tenth more light to the area it occupies than the background light. The photocathode dark emission of the image-converter tube reduces the effective contrast of the star to the background. Therefore, for large telescopes of great light gathering power and where it can be safely assumed that the flux of light is sufficient to prevent failure of the photographic reciprocity law, if one has all the time needed for conventional photography he will be able to photograph stars as faint or even fainter, without the uncooled image-converter tube than with it, while using the same photographic emulsion. The advantage of the tube is that with it, a shorter exposure time is needed than would be the case with conventional photography. Hence, smaller telescopes may be used without the failure of the photographic reciprocity law making the exposure impossible. Another possibility with the image-converter tube would be to use plates with finer grain than would otherwise be possible, provided the image-converter system has sufficient resolution. The finer grained plates normally require longer exposure times for the same density than the coarser grained plates do, but the finer grained plates show more detail, and also smaller differences in local density variations can be detected. Thus, the gain in the image-converter tube makes it possible to use reasonable exposure times with the finer grained plates. The shorter exposure times may be very important for tracking purposes. Performance beyond the limit of the image-converter tube requires instrumentation of a different type, a type that will provide an increase in contrast and permit a dynamic suppression of the background.

An instrumentation fulfilling the requirements of providing good contrast and permitting suppression of nearly all the background, yet at the same time having exceptionally high sensitivity, was developed by the Aeronautical Research Laboratory of the Wright Air Development Center as a result of several years of research. The best method of providing the required increase in contrast and suppression of the background was found to be that of employing a scanning system (closed circuit television) in which the threshold can be determined arbitrarily by proper biasing of the video amplifier system employed. The pickup tubes available for commercial television are of limited suitability for low light level work because their performance at low light level is restricted by the noise in the scanning beam, which appears as additional fluctuating background. This restriction does not exist in the new intensifier-image-orthicon tube which was developed through this research. The new tube was produced under a research contract with the RCA Laboratories at Princeton, New Jersey, by Dr. G. A. Morton and Dr. J. E. Ruedy. Greatly increased sensitivity is achieved by employing preamplifier stages similar to the cascaded image-converter tube, ahead of the noise-producing scanning section. The scintillations in the dark current of the first photocathode may be observed with such a tube (fig. 1a, 1b), since the constant value of the background that results from the dark current may be suppressed by methods described later.

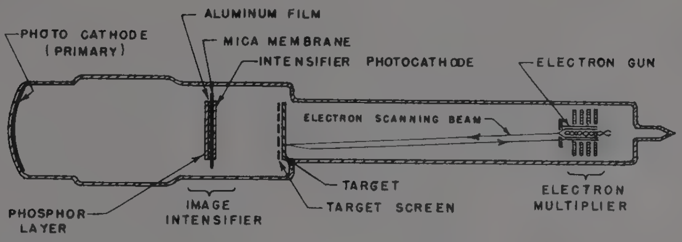


FIGURE 1a. Single stage image optical amplifier tube. **Note:** Aluminum film should read phosphor layer; phosphor layer should read aluminum film.

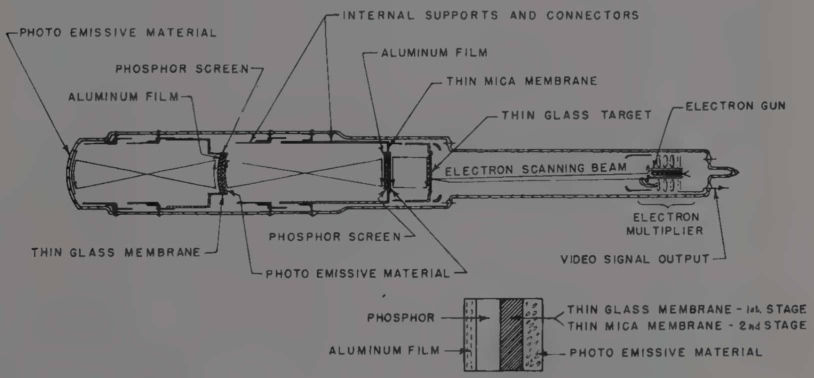


FIGURE 1b. Two stage intensifier image orthicon.

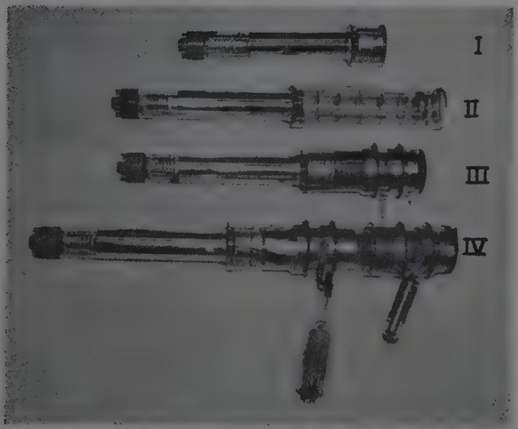


FIGURE 1c. I—Ordinary 5820 image orthicon. II—Westinghouse transmission secondary emission experimental intensifier. III—R.C.A. single stage intensifier orthicon. IV—R.C.A. double stage intensifier orthicon.

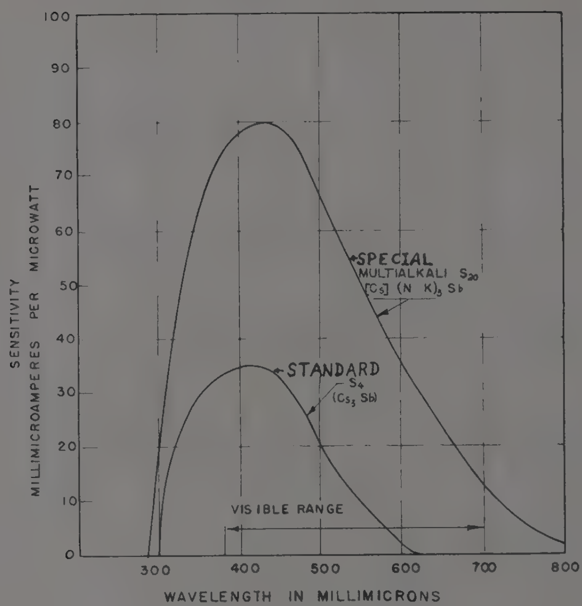


FIGURE 2. Comparative absolute sensitivity of photosurfaces.

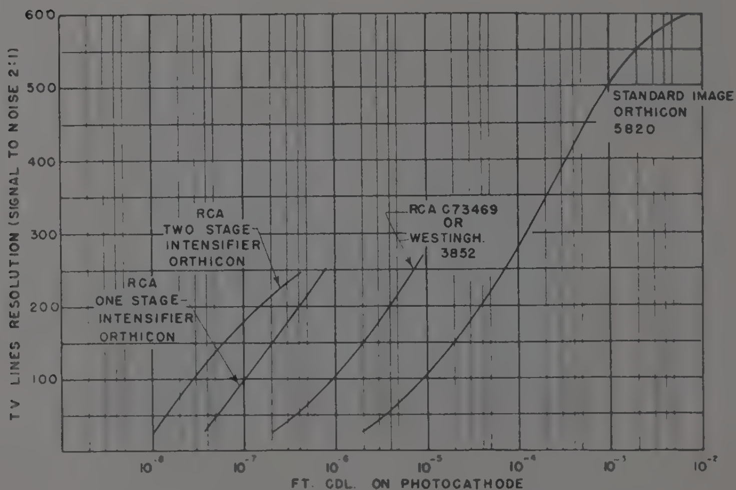


FIGURE 3. Pickup tube performance for exposure time = 1/30 sec.

The photocathodes of the new intensifier-image-orthicon tube have an output as high as 240 μamp per lumen (fig. 2). This is four times the output previously available. These photocathodes have their threshold sensitivity at approximately 8700 Å, which is two thousand angstroms further into the red than that of previously available photocathodes. It is remarkable that the higher yield of these photocathodes and the increased sensitivity to radiation in the near infrared is possible without any significant increase in the dark current. The dark current is each second less than two thousand electrons per square millimeter at 25° C. The intensifier screens that are used consist of a combination of phosphor and photocathode and yield an output of ten to fifteen electrons for each electron that strikes them. Combining the new photocathode and two of the new intensifier screens yields an intensification of the order of one thousand times

FIGURE 4. Astronomical telescope modified for optical amplification.

(Morton and Ruedy, 1958). It therefore makes possible imaging with about one-thousandth of the light previously required and it becomes a very attractive tube for astronomical work and other low light level observations (Gebel, 1957, 1959).

The desired increase in contrast for star photography can be obtained by direct suppression of a constant "background" from the whole scene by means of the electronic amplifier. The amount of background which can be suppressed is determined by the statistical fluctuations in the background. Theoretically, the ratio of the star signal to these fluctuations can be increased by increasing the length of time utilized in storing the electronic image on the target plate before it is removed by the scanning beam (Gebel and Devol, 1959). Practically, the limits placed on the sensitivity of the equipment and on the enhancement of the contrast lie in the storage capability of the target plate. An effective light flux

amplification of 10^9 has been attained in the research and operation is possible at minimum photocathode illumination of approximately 10^{-8} foot-candles. Performance curves for a commercial image orthicon and for two intensifier-image-orthicons are shown in figure 3.

Determination of the capabilities of the equipment and the areas requiring further research was necessary. The equipment was installed on the 10-inch refracting telescope of the Weaver Observatory at Wittenberg University for this purpose and many astronomical observations were taken (Gebel, 1958, 1959; Gebel and Wylie, 1958) (fig. 4, 5). The functions of the essential parts of this

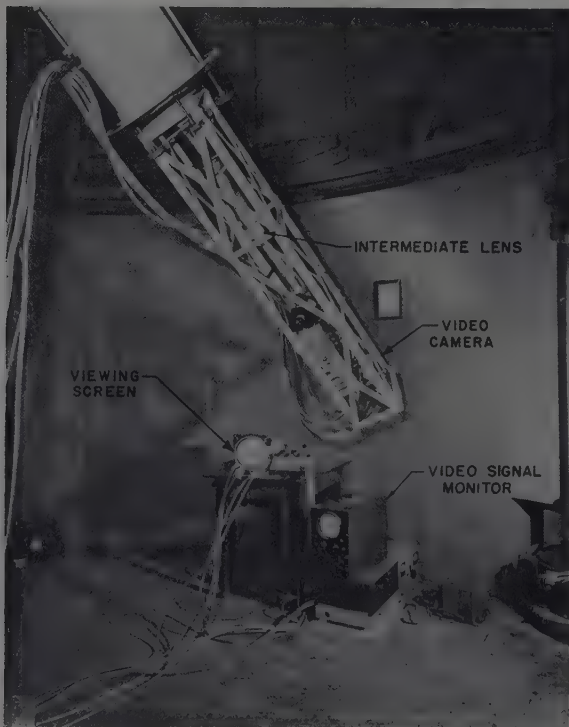


FIGURE 5. Optical amplifying system showing mounting.

type of equipment are identified schematically in the block diagram in figure 6. Modification of the image is electronically accomplished in four stages, as indicated in the diagrams of figure 7, which represent the signal obtained as the scanning beam moves across the target plate. The background noise is illustrated by the waviness in sections *ab* and *cd* of diagram A (fig. 7a). Noise is also present in *ef*, as is indicated by the waviness superimposed on the portion of the signal caused by the celestial body. The upward slope from left to right is the result of a gradual shading in the sky within the field of view.

Two sky shading controls correct the signal from situation A to situation B. One control corrects for the vertical and the other for the horizontal shading variations.

The picture gamma control circuit is an electronic nonlinear device that permits one to increase the contrast. The effect of such an increase is displayed in diagram C, where the upper portion of the signal is accentuated in comparison with the lower portion.

The threshold limiter makes it possible to suppress the lower portion of the signal below a selected level, so that it constitutes that part of the circuitry which weakens or eliminates the background. The result is diagram D (fig. 7b). Finally, the amplitude limiter permits one to limit the upper portion of the signal, thus removing the fluctuations in that portion of the signal caused by the celestial body (diagram E).

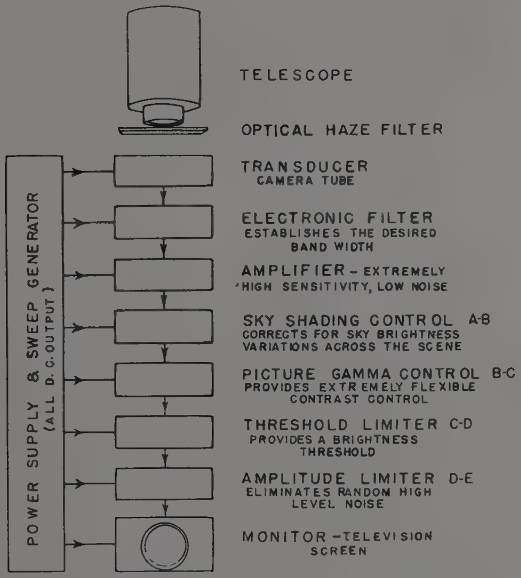


FIGURE 6. Block diagram of telescope and optical amplifier.

The focal length of the telescope was changed from 3.8 m to an equivalent focal length of 15 m by employing an intermediate system. The purpose was to match the resolution of the telescope with the highest resolution of the intensifier-image-orthicon. This is approximately ten optical lines per millimeter at the photocathode (Gebel, 1959). The revised optical system is shown schematically in figure 8.

ASTRONOMICAL PHOTOGRAPHS

Many photographs of celestial bodies were taken for the purpose of exploring the astronomical possibilities of this type of equipment. Unfortunately, the supply of intensifier-image-orthicons is limited at present. Such tubes are hand made, they are very expensive, and they have a short lifetime that averages only

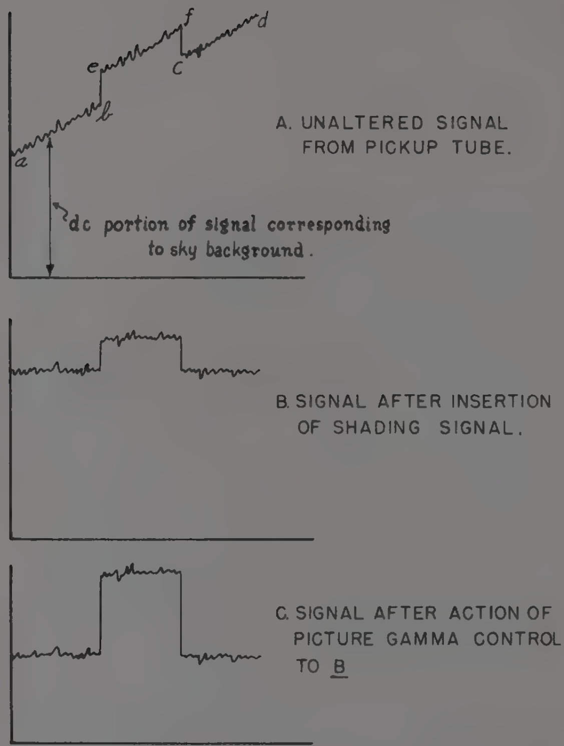


FIGURE 7a. Contrast, background, and noise correction.

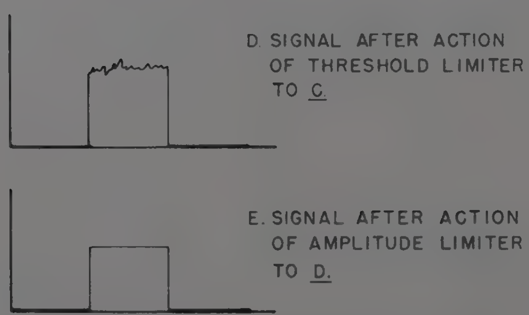


FIGURE 7b. Contrast, background, and noise correction.

about fifty hours. For these reasons another type of pickup tube that was newly designed and specially made (RCA C 73469, Westinghouse 3852) was used in those cases where high sensitivity was not needed. These tubes have a multialkali photocathode, and have improved sensitivity through wide spacing of the target plate meshwire assembly. The performance of these tubes in comparison with conventional tubes may be seen in figure 3. The lifetime of these tubes is several hundred hours since no intensifier is placed ahead of the image section. The cost of this type of tube is much less than the intensifier-image-orthicon tube. Furthermore, the use of the longer-life tube made it possible to test, under all observing conditions, the background suppression and the sky shading capabilities of the specially designed video amplifier.

Figures 9 to 14 are some of the typical pictures taken during daytime hours when the sun was above the horizon. Figures 15 to 18 are typical night time pictures. The explanation of each picture tells which tube was used.

Calculations indicate that with this type of instrumentation and using the Hale telescope of 200-inch aperture, a nighttime exposure of 100 seconds would reach a star of 26th magnitude (Gebel, 1959). The exposure time in the photographs shown here was a twenty-fifth of a second but a shorter time would have been sufficient in a great many cases. The large size of the star images in the photographs is due to the bad seeing that is characteristic of daytime observations. The bad seeing is a rapid fluctuation in the star's brightness accompanied by small

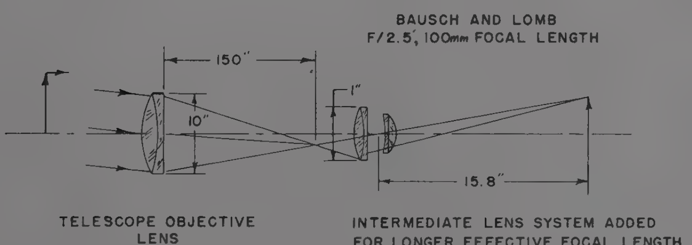
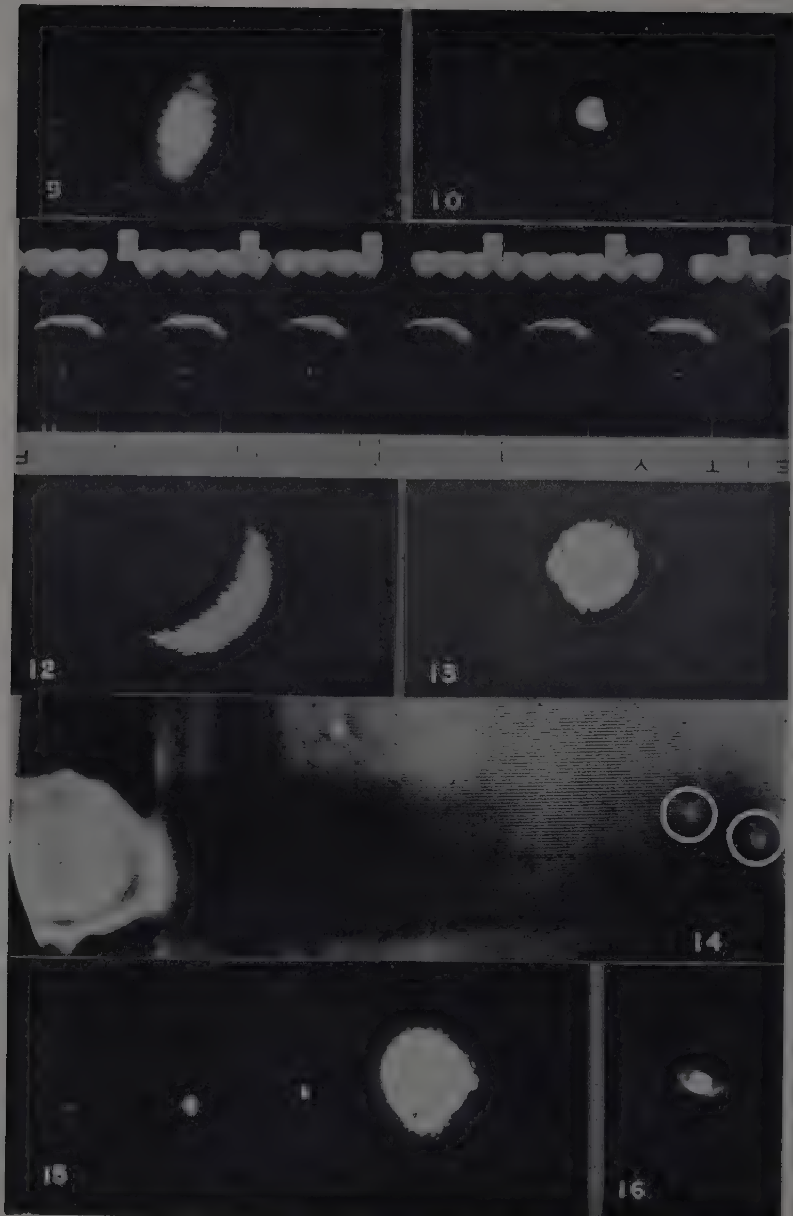


FIGURE 8. Optical system.

and equally rapid changes in apparent position. These jitters are produced by the dynamic changes in the different layers of air through which the beam of light passes. Springfield, Ohio, is an industrial city, and in Springfield it is unusual to have seeing better than three to five seconds of arc at night, and as much as twenty seconds has been observed during the day. The image of Arcturus in figure 10 corresponds to approximately ten seconds of arc. Since the potential resolution of the combined optical system at 15 m equivalent focal length was found to be 2.5 seconds of arc, the area covered by the image is about sixteen times the smallest that can be resolved. It follows that the quanta of light were distributed over an unnecessarily large area on the photocathode. This results in a lower contrast toward the background. Optimum detectivity is achieved if the image from the celestial body covers just one spot of resolution of the sensor. The same reasoning applies to the observations of the planets. In astronomical photography a planet of a certain apparent magnitude requires a longer exposure time than a star of the same magnitude. The same amount of light is distributed over a larger area, since the planet is not a point source (Gebel, 1959).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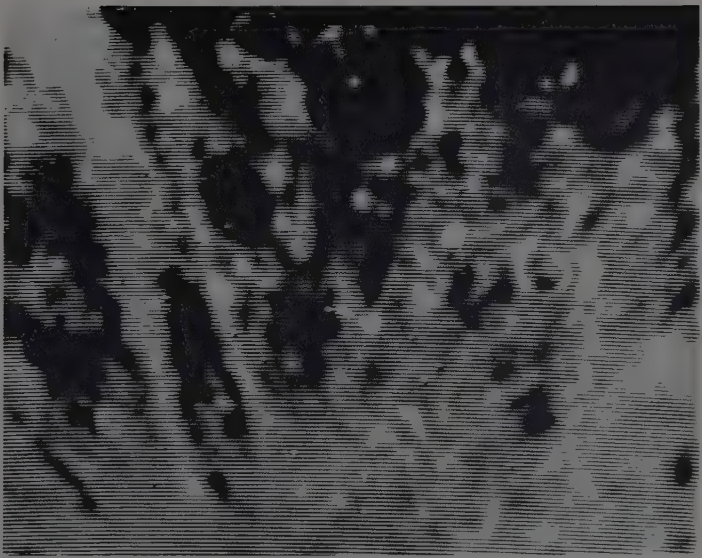

FIGURE 17a. Night shot of moon, area of Crater Tycho, at 23:30 EST, August 27, 1958. Westinghouse tube type 3852. 15 meter focal length.

A conclusion from the foregoing is that, in order to achieve optimum conditions for photographing point sources, one should adjust the focal length to match the seeing conditions so that all quanta of light are concentrated on one point of resolution.

Figure 11 displays a few frames of a midafternoon motion picture of the star Vega. The frames show the jitters caused by the bad seeing conditions. The picture of Venus (fig. 12) was taken at 2:00 PM on January 9, 1958. It was taken

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EXPLANATION OF FIGURES IN PLATE

9. Saturn at 19:25 EST, July 24, 1957. Sunset was 19:57 EST, elevation of Saturn was 26° and angle between it and sun was 125°. Cat. Mag. was 0.5, RCA tube type C73469. Film exposure time was 1/25 sec.
10. Arcturus at 15:20 EST, August 6, 1957. Sunset was 19:43 EST, elevation of Arcturus was 53° and angle between it and sun was 73°. Cat. Mag. was 0.2, RCA tube type C73469. Film exposure time was 1/25 sec.
11. Vega at 14:00 EST, September 11, 1957. Sunset was 18:50 EST, elevation of Vega was 25.6° and angle between it and sun was 102°. Cat. Mag. was 0.1, RCA tube type C73469. Film frame rate was 24 per sec.
12. Venus at 14:00 EST, January 9, 1958. Sunset was 17:28 EST, elevation of Venus was 35° and angle between it and sun was 28°. Cat. Mag. was −4.2, RCA single stage intensifier tube. Film exposure time was 1/25 sec.
13. Jupiter at 08:16 EST, January 19, 1958. Sunrise was 07:54 EST, elevation of Jupiter was 32° and angle between it and sun was 88°. Cat. Mag. was −1.6, RCA tube type C73469. Film exposure time was 1/25 sec.
14. Jupiter and satellites 1 and 2 at 07:37 EST, February 9, 1958. Sunrise was 07:36 EST, elevation of Jupiter was 31° and angle between it and sun was 108°. Cat. Mag. of satellites was 5 and 6, RCA tube type C73469. Film exposure time was 1/25 sec.
15. Night picture of Jupiter and Galilean satellites at 20:30 EST, May 12, 1958. Cat. Mag. of satellites was 5 and 6. Westinghouse tube type 3852. Film exposure time was 1/25 sec.
16. Night picture of Saturn at 21:10 EST, August 27, 1958. RCA single intensifier tube. Film exposure time was 1/25 sec.

FIGURE 17b. Night shot of moon, area of Crater Tycho, at 23:35 EST, August 27, 1958. Conventional photographic methods using 35mm Tri-X film; 15 meter focal length.

FIGURE 18. Russian carrier rocket of Delta I passing, with Vega in field of view, at 20:29 EST, August 25, 1958. Westinghouse tube type 3852. Film exposure time was 1/25 sec. Lens system, Bell and Howell, f 0.7; 120 mm focal length.

with a single stage intensifier-image-orthicon tube. The distinct horizontal lines in the picture are the scan lines. The angular diameter of Venus was 53 seconds of arc at the time. Venus is reproduced by 39 lines, which means that each line represents 1.3 seconds of resolution. The fluctuations caused by the scintillations of the air were a multiple of this value, so the air scintillations represent the true limiting value of the resolution for this observation. Since the proper choice of the equivalent focal length permits a matching of the fluctuations to the resolution of the pickup tube and the scanning lines, one can always adjust the system so that the seeing conditions determine the limit in resolution.

The work at Wittenberg University was undertaken to show the potentialities of a system of optical amplification for astronomical observations using the principles of closed circuit television. The remarkable ability to control contrast and to suppress the background makes this system useful also for artificial satellite observation and tracking during the daytime hours. It is useful for aerial reconnaissance and for many other purposes. In space exploration the advantage of this kind of optical amplification is obvious because the pictures can easily be transmitted over cosmic distances.

SUMMARY

The advantages of observing and photographing celestial bodies with a light amplifier that employs the closed circuit television principle are explored and treated here. Special pickup tubes were developed to insure optimum performance. The electrical signals from the pickup tube are electronically amplified and modified. The image is reproduced by a cathode ray tube and photographs may be obtained from the screen of this tube.

The electronic amplification of the electrical signal permits light intensification of 10^9 times. The modification of the signal makes almost complete suppression of the background possible. It permits astronomical observations during the day and also at night that are not possible with systems in which the background cannot be suppressed. Photographs of celestial bodies taken at the Weaver Observatory of Wittenberg University are shown here.

ACKNOWLEDGMENT

The authors wish to express their gratitude to Wittenberg University for the use of the telescope, and to the other persons who participated in the work. Heinrich Bost made the mechanical arrangements. Roy Hayslett and Harry Beck did the technical work on the electronic arrangements of the light amplifier, and they obtained the photographic recordings. Richard Palmer and Myron Yang also gave valuable technical assistance. The authors acknowledge with thanks the contributions of these members of the team.

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THE OCCURRENCE AND DISTRIBUTION OF *HIEROCHLOË ODORATA* IN OHIO[1]

KNUT NORSTOG
Wittenberg University, Springfield, Ohio

Hierochloë odorata (L.) Beauv. is the sweet smelling grass that the Indians of the Traverse Bay region of Michigan use in making souvenir baskets and other woven articles. In northern Europe, where the species also occurs, its leaves were formerly scattered in front of church doors on saints' days, and Icelandic maidens

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placed bundles of *Hierochloë* leaves among their linens to serve as natural sachets. The lingering fragrance, which accounts for these uses, is due to coumarin, and is responsible for such colloquial names as Sweetgrass and Vanilla Grass.

Hierochloë odorata is rather widely distributed in the Northern Hemisphere, occurring in both the Old and New Worlds. In North America it is confined chiefly to areas north of the fortieth parallel, although it has been found also in the mountains of Arizona and New Mexico. Throughout this range it is extremely local and is represented by scattered populations in moist habitats.

FIGURE 1. *Hierochloë odorata* (L.) Beauv. var. *fragrans* (Willd.) Richter.

Norstog (1957) has previously reported the occurrence of polyembryony and possibly apomixis in the reproductive cycle of the species. The present study is, in part, an extension of that former investigation, and has as its objective the analysis of the occurrence, distribution, chromosome numbers, and reproduction of populations of Sweetgrass in Ohio.

MATERIAL AND METHODS

Information on the distribution of *Hierochloë odorata* in Ohio was obtained by means of a postcard survey of college and university herbaria within the state and of various herbaria in other states. The data obtained as a result of these contacts are summarized in figure 2.

Whenever the descriptive information accompanying herbarium specimens of Sweetgrass was specific enough, the areas in which the original collections had been made were revisited. In some instances, of course, it was obvious that such

trips would be completely fruitless. For instance: three herbaria, the Gray Herbarium of Harvard University, the New York Botanical Garden, and the Herbarium of The Ohio State University, have specimens collected in Columbus, Ohio in the early 1800's when that city was only a village. Now the only place in the metropolis where Sweetgrass occurs is the Herbarium of The Ohio State University.

Additional field trips were undertaken in the hope of discovering new locations. In all, seven populations of Sweetgrass were located, two for the first time. Plants from these areas subsequently were removed to the greenhouse of Wittenberg University for further study. The soil and roots of these transplants were wrapped in cheesecloth and suspended in clean clay pots which were, in turn, set in shallow

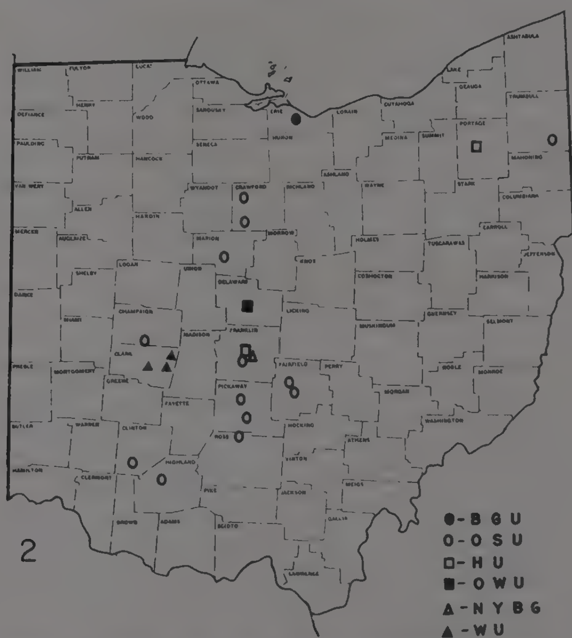

FIGURE 2. Locations of populations of *Hierochloë odorata* which are represented by herbarium specimens. BGU—Bowling Green State University, OSU—The Ohio State University, HU—The Gray Herbarium, Harvard University, OWU—Ohio Wesleyan University, NYBG—Herbarium of New York Botanical Garden, WU—Wittenberg University.

pans of water. After a time, the soil-free roots which grew through the cloth were removed and processed by a technique suggested by Sigurbjornsson (personal communication). In this method the root tips are collected in mid-afternoon, immersed in distilled water, and placed in a refrigerator. This treatment holds the cells in the metaphase and also tends to separate the chromosomes. The following morning the root tips are placed in Farmer's fluid for at least 30 minutes and then removed, as needed, to a small beaker containing 5 ml of aceto-carmine solution and one drop of concentrated hydrochloric acid. This is heated to

boiling momentarily and allowed to cool. The terminal millimeter of the root tip is placed in a drop of aceto-carmine on a slide, teased apart with a steel needle, and squeezed under a coverslip. This method has produced better results with *Hierochloë* root tips than any other method recommended for such recalcitrant material as the root tips of grasses.

In addition to the collections of living plants, specimens were also collected and preserved by drying for use in the determination of relative fertility and the occurrence of polyembryony. This was done very simply by counting the florets in a number of inflorescences, threshing these through sieves, and examining the separated caryopses under a dissecting microscope.

OBSERVATIONS

It has become evident that *Hierochloë odorata* has a rather limited distribution in Ohio, not only in terms of the number of separate populations but also in the number of plants per stand. It should be remembered that only two new locations, both in Clark County, have been added to the total for Ohio as a result of the present study in spite of an extensive search.

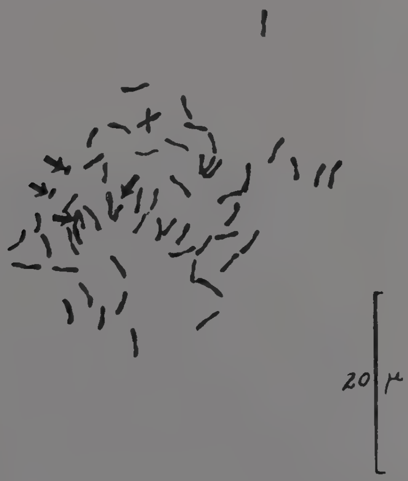

FIGURE 3. Somatic chromosomes from root tips of *Hierochloë odorata*, specimens from Champaign County, camera lucida tracing, arrows point to long and short pairs of chromosomes referred to in text.

Figures 3 and 4 are representative of the chromosome complements found in the plants from the seven extant populations of *Hierochloë odorata* that were studied. In all instances the somatic chromosome number was found to be 56. A pair of short, apparently telocentric, chromosomes and a long pair were distinguishable in several of the preparations. Some size variation was apparent in the other chromosomes but their tendency to clump interfered with detailed observations of their morphology.

Examination of the inflorescences of specimens from the seven populations revealed that the fertility of Sweetgrass in Ohio is very low. The highest percentage, that found in plants in Marion County, was less than half that reported in plants from southern Michigan (Norstog, 1957). Twin embryos were found to have been produced by plants from five of the seven areas. The absence of

polyembryony in the other two populations may not be significant because of the low fertility encountered. These data are presented in table 1.

TABLE 1

Fertility and polyembryony in Ohio populations of Hierochloë odorata

Area	Total florets	Fertile florets	Fertility	Twin embryos
Highland Co.	526	21	4.0%	6
Ross Co.	280	17	6.1%	0
Harmony, Clark Co.	851	15	1.7%	4
New Moorefield, Clark Co.	1064	20	1.9%	1
Champaign Co.	945	20	2.1%	4
Marion Co.	340	36	10.6%	1
Crawford Co.	757	0	0.0%	0

Hierochloë odorata grows best in places in which it is relatively undisturbed. Its requirement for a constant and high moisture supply limits its survival in Ohio where so many wetlands have been drained, and it apparently cannot withstand intensive grazing, although the reason for this may be a subtle one since cattle are said to find the coumarin taste of the grass rather bitter. None of the populations are very extensive, and the grass occupies a rather sterotyped and

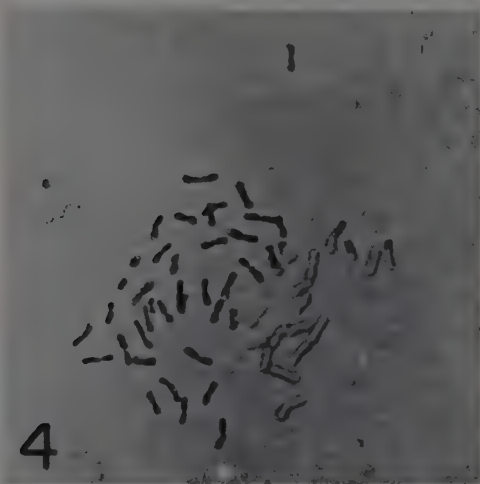

FIGURE 4. Photomicrograph of the original preparation of chromosomes shown in figure 3.

restricted ecological position. Figure 5 represents, diagramatically, the relationships observed in three of the seven areas; the other four were quite similar except that the Big Bluestem Grass, *Andropogon gerardi* Vitman., was absent. Sweetgrass occupies a position in the soil-moisture spectrum between that of plants such as species of *Carex* which grow in shallow water and saturated soils, and the Big Bluestem and others which prefer a dryer substratum. The soils ranged from clay

to muck types, but all were neutral to slightly alkaline, pH 7 to 8. Two of the areas were railroad rights-of-way, and the other five were roadsides. In six of these *Hierochloë* grew only within the right-of-way and did not extend into adjacent farmland, but in the seventh, the Ross County location, the grass also grew along the edges of an undrained marsh. The largest stand was found along U. S. Highway 40, east of Harmony in Clark County. Here the grass grows luxuriantly in the ditch along the north side of the road but not, however, in an adjacent wet meadow which is pastured at present.

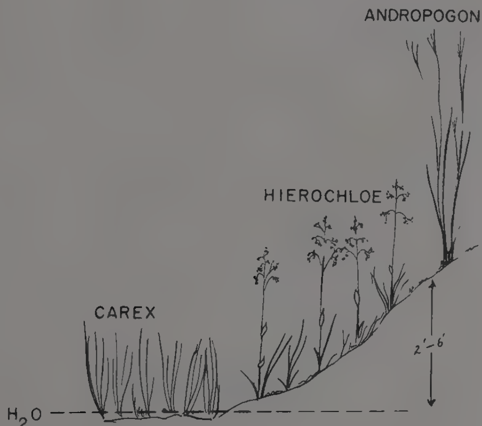

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FIGURE 5. Diagram illustrating the habitat relationships of several Ohio populations of *Hierochloë odorata*. Plants shown are an unidentified species of *Carex* in vegetative state, *Hierochloë odorata*, and *Andropogon gerardi*.

DISCUSSION

Fernald (1917), in discussing a tall form of Sweetgrass from Connecticut, called attention to the existence of two varieties of *Hierochloë odorata*. One of these is found in Europe and also in the Rocky Mountain region where, he stated, it intergrades with the eastern race. Fernald designated the latter as variety *fragrans* (Willd.) Richter, pointing out that at one time it was thought to be a distinct species, *Holcus fragrans* Willd. Curiously Fernald later apparently abandoned this separation since in the eighth edition of *Gray's Manual of Botany* (1950) variety *fragrans* is not listed. After examination of collections from Iceland and North America, I feel that two varieties can be distinguished. One of these, to which the Ohio specimens belong (fig. 1), is certainly more robust than the other.

Somatic chromosome numbers of 28, 42 and 56 are listed for *Hierochloë odorata* by Darlington and Wylie (1955). Since the base number in *Hierochloë*, as in many other grasses, is seven, these represent tetraploid, hexaploid and octoploid numbers. Löve and Löve (1955) report that specimens from Iceland, Sweden, Germany, and North America ("at least west to Manitoba") have 28 somatic chromosomes, while the chromosome number is 42 in plants of *H. odcrata* from Russia, Finland, and Japan. The latter recently were identified by Kawano (1959) as *H. odorata* (L.) Beauv. variety *pubescens* Krylov. Church (in Myers,

1947) reported that certain specimens of *H. odorata* had 56 chromosomes. Löve and Löve, however, suggest in this connection ". . . since this last number [56] is also typical for the closely related species *H. alpina* (Sw.) R. & S., it might perhaps have been determined on specimens more correctly referred to that taxon . . . ." Church (personal communication) has assured the writer that the plants on which the determination was made were definitely *H. odorata*. The identical chromosome number in the Ohio specimens confirms this assertion and also seems to justify Fernald's earlier conclusion that two varieties of *Hierochloë odorata* exist in North America. Variety *fragrans* (Willd.) Richter, the robust form having a chromosome number of 56, occurs in the eastern half of the United States and perhaps more widely; variety *odorata*, which is somewhat smaller in size and has a chromosome number of 28, is found in northern Europe, Iceland, Greenland, and northern and western North America.

The question of intermediates between the two varieties of Sweetgrass, as reported by Fernald (1917), needs further study. If they are actually set apart by different chromosome numbers, as well as by morphological differences, the matter of intermediates requires substantiation for it is not known that the tetraploid plants will hybridize with the octoploids, although the existence of hexaploids certainly suggests that this may have occurred in the past. I have examined some 300 spikelets of specimens gathered in southern Iceland, and found in them only five viable seeds. When these were germinated they produced tetraploid seedlings which were decidedly smaller than seedlings of the octoploid Ohio specimens.

At the time polyembryony was initially reported in a population of this species in southern Michigan (Norstog, 1957), it was suggested that the specimens studied were apomicts. This has been confirmed recently by myself, although it is as yet unpublished. The 56 chromosome plants from Michigan, and probably those from Ohio, are characterized by a type of reproduction that may be exclusively aposporous and apomictic. Polyembryony is of frequent occurrence, has its origin in multiple, aposporous embryo sacs, and is, therefore, indicative of the aposporous and apomictic nature of the populations in which the phenomenon occurs. In light of the apomictic nature of the octoploid variety of *Hierochloë odorata* and the infertility of the tetraploid populations, it is obvious that the matter of intermediates between the two requires clarification.

It is interesting that Sweetgrass appears to have found a niche along the Ohio roadsides. Neither mowing nor spraying seems to affect adversely populations so located. Presumably this is because these plants usually reproduce by rhizomes, and because the herbicides used have little effect on grasses. Despite its infertility and the discontinuity of its habitat, where it has become established *Hierochloë* is quite vigorous and gives every evidence of remaining in situ indefinitely to add a touch of interest to the local scene for those who are sensitive to the variety and beauty of the grasses.

SUMMARY

Hierochloë odorata, a fragrant grass of the boreal wetlands, occurs in Ohio in a few widely scattered areas. It has been able to survive along the roadsides and railroad rights-of-way, but it is not able to withstand the drainage of its habitat and attendant intensive land usage.

The fertility of *Hierochloë* is quite low. The grass is apomictic and its propagation seems to be largely vegetative. This probably stands in the way of colonization of suitable niches unless they happen to be confluent with those in which Sweetgrass is already established.

The somatic chromosome number of *H. odorata* in Ohio was found to be 56, which supports the previously reported determination of Church (in Myers, 1947). It is suggested that the existence of two races or varieties of *H. odorata* postulated

by Fernald (1917) can be reconciled with the circumstance of the existence in North America of populations of this species having somatic chromosome complements of 28 and 56, respectively.

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SURFICIAL MATERIALS AND SOILS OF PAULDING COUNTY, OHIO*

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Vast differences exist among the major dark-colored gleyed soils of the lake plain of Paulding and adjacent counties in northwestern Ohio. A complete detailed soil survey was initiated in Paulding County in August, 1952. Shortly after these operations were begun, it became apparent that not only were there major differences among these soils, but that they blended very imperceptibly from one to another. These variations accounted for highly significant differences in soil management, crop yields, and prices paid per acre for farm land. The basic reason for these differences had not been determined.

PURPOSE OF STUDY

This study was set up with three purposes in mind: 1) to determine why these soils behave so differently in their respective areas of occurrence when there is no sharp line of demarcation; 2) to determine whether these variations are due to geologic factors; and 3) if geologic phenomena are responsible for the differences in these soils, what are they and how could they be used as an aid in mapping the distribution of these various soils?

INTRODUCTION

This paper concerns primarily the Paulding Basin, which includes all land lying within the area that has as its perimeter the highest Maumee beachridge on the south from Findlay to Fort Wayne, and on the northwest from Fort Wayne

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to the vicinity of West Unity in Williams County, and the Defiance moraine on the east from the vicinity of Wauseon in Fulton County to Findlay (see fig. 1).

In a normal year a traverse from the southwestern corner to the northeastern corner of Paulding County discloses a significant gradual decrease in crop yields, much thinner average crop stands, a greater increase in occurrence of crop failures, a greater degree of damage to growing crops by heavy rainfall, a greater degree of ponding of water on the soil surface, much slower response to drainage, the need for considerable more tillage in the preparation of an adequate seedbed, and a progressively later planting season in the spring.

Failures to obtain good stands of crops immediately following seeding are common in large portions of eastern Paulding County and adjoining areas in neighboring counties. During dry periods, seeds do not sprout because the soil surface is too cloddy and becomes too dry. During excessively wet weather, the soil surface runs together, becomes puddled and dries out very slowly. These conditions are especially troublesome on the lower elevations of the Paulding Basin.

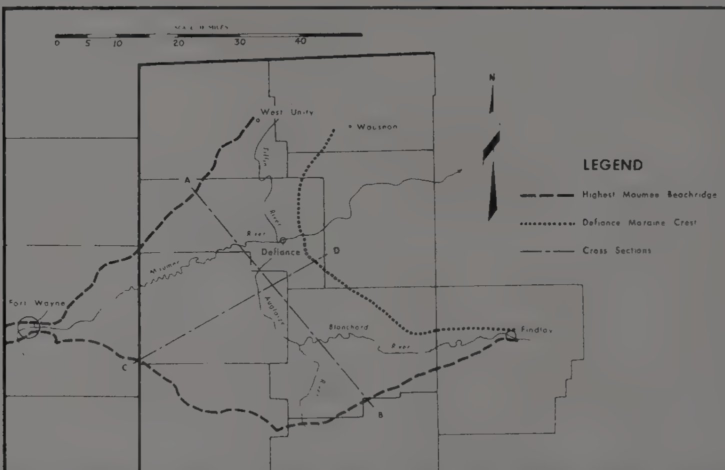

FIGURE 1. Location of elevation cross-sections AB and CD in Paulding Basin, northwestern Ohio.

In the heart of the Paulding Basin many soils respond very slowly to tile drainage. Relatively few tile drainage systems have been installed. Toward the perimeter of the basin with increasing elevation more and more tile have been used for drainage. The soils show significantly greater beneficial response to artificial drainage than those at lower elevations near the center of the basin.

Land values in 1952 for the moderately fine-textured soils in the southwestern part of the county varied from 350 to 400 dollars per acre. Toward the northeastern part of the county land values tended to decrease progressively to less than 150 dollars per acre for the very fine-textured soils.

Planting dates, barring interruption by wet weather, are about two weeks earlier in the southwestern than in the northeastern part of the county.

A traverse from any point on the Defiance moraine or the highest Maumee beachridge into the center of the Paulding Basin reveals these same problems to be just as discernible and significant.

The first soil survey of Paulding County recognized the deposition of lacustrine

materials on the glacial till, but at that time it was the opinion of Lewis and Shiffler (1915, p. 14) that these lacustrine deposits were present on nearly all areas in the lake plain. The dark colored lake plain soils were all classified as Clyde clay. The Paulding soil series was distinguished from Brookston soils and established during the soil survey of Putnam County (Taylor et al., 1936). They considered these soils to have "extremely heavy and extremely impervious silty clay" subsoils underlain by "impervious heavy plastic glacial till material." Rogers and Fowler (1947) defined the Paulding series as being "developed on very heavy calcareous glacial clay till of lake plains." It was described as differing from the Brookston soils of the lake plain (now called Hoytville) "in having heavier, more impervious clay subsoils and substrata that contain little or no coarse material." These concepts were used by the Soil Conservation Service in mapping individual farms prior to 1952.

DESCRIPTION OF THE PAULDING BASIN

The topography, except in the vicinity of the beachridges, moraines, and stream channels, is very smooth and has very low gradient. Topographic maps of the U. S. Geological Survey show the gradient to vary between 4 and 7 ft/mile in the outer portion of the basin and between 1 and 3 ft/mile in the lower portion. In some areas the gradient is less than 1 ft/mile.

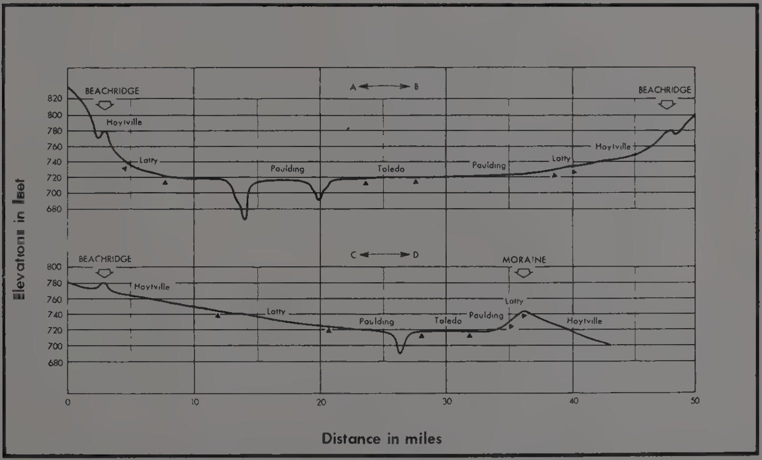

FIGURE 2. Elevations along cross-sections AB and CD, Paulding Basin, northwestern Ohio.

The Maumee River falls at the rate of 1.3 ft/mile (Krolczyk, 1954, p. 33). That portion of the Auglaize River within the lake plain has a gradient of about 1.8 ft/mile.

The location of two cross-sections of the basin are shown in figure 1. Cross-section AB begins at a point behind the highest northerly Maumee beachridge about 2 miles southwest of Williams Center in Williams County, extends in a southeasterly direction and crosses the highest southern Maumee beachridge in Allen County about 2.5 miles southwest of Columbus Grove. Cross-section CD begins behind the highest southerly Maumee beachridge at a point about 1 mile west of the Ohio-Indiana line and extends in an east-northeast direction across the Defiance moraine about 1 mile southeast of Ayersville in Defiance County.

These cross-sections (fig. 2) portray the depressional terrain that constitutes

the Paulding Basin. Only the major drainage channels are shown. Most of the highest Maumee beachridge lies between elevations of 780 and 790 ft. That portion of the Defiance moraine lying adjacent to the major part of the Paulding Basin rises from the basin floor to elevations between 730 and 750 ft. The elevation of the lowest part of the basin floor, exclusive of those areas affected by erosional factors, is about 710 ft.

Several significant areas of sand, 50 to more than 200 acres in extent, occur at elevations of 710 to 725 ft in Auglaize, Brown, and Emerald Townships in Paulding County. Small widely scattered bodies of sand, 0.5 to more than 10 acres in extent, are found in many parts of the basin. These sand areas are not shown on any of the figures because of their erratic nature of occurrence.

The southern two-thirds of the basin is underlain with limestones of the Columbus and Monroe groups; the northern one-third is underlain with Ohio shale. A small area at the northern edge of the Paulding basin is underlain with basal shales of the Mississippian formation. (Stout et al., 1944).

The area has been covered by several distinct stages of glaciation, the last one being the Wisconsin. There is abundant evidence that the lake basin existed during at least one of the earlier stages of glaciation (Leverett and Taylor, 1915, p. 318). Just prior to the formation of any known glacial lakes the ice was "in a waning stage of the Fort Wayne phase of the Cary glacial substage in the Erie Basin" (Hough, 1958, p. 139). Hough (1958, p. 140) also pointed out that the "first major lake stage in the Erie basin was formed by recession of the margin of the glacial ice eastward from the southwestern end of the basin, leaving a low area between the ice and the Fort Wayne moraine." This lake had an elevation of 800 ft and discharged to the Wabash River at Fort Wayne (Hough, 1958, p. 140). Leverett and Taylor (1915, p. 322) suggested that the ice retreated as much as 25 to 30 miles behind the position of the Defiance moraine before readvancing to that position. Hough (1958, p. 144) believes that the ice may have retreated much farther than this point before its readvance. The Defiance moraine marks the position of the ice border during a considerable part of the life of the First Lake Maumee (Leverett and Taylor, 1915, p. 279).

Vegetation

In the early days the Black Swamp of which the Paulding Basin is a part was described as a "morass that varied seasonally as well as annually with changes in precipitation" (Kaatz, 1955, p. 2). Kaatz (1955, p. 7) referred to it as a "thick and almost tractless forest." The poorly drained soils of the Paulding Basin were covered with a dense growth of black and white ash, American elm, shagbark and big shell bark hickory, basswood, swamp white oak, pin oak, burr oak, sycamore, silver maple, and cottonwood; some of the boggy areas were covered with wet land grasses and sedges; the better drained areas supported a dense growth of beech, basswood, white oak, red oak, and sugar maple (Baker et al., in press).

Nearly all of the original dense stand of timber has been cleared. To some extent the few remaining areas of timber have changed in character. This condition is especially true in areas of the Paulding soil series where pin oak and swamp white oak have become major species.

PROCEDURE AND OBSERVATIONS

The Humic-Gley soils were selected for this study because they represent nearly 75 percent of the total soil area on the lake plain in the Paulding Basin. After some initial study it was apparent that the Humic-Gley soils above an elevation of about 735 ft had developed from calcareous glacial clay till. The till displays evidence of having been reworked and the surface smoothed to some degree by wave action in glacial Lake Maumee. However, there is little evidence of any significant amount of deposition of lacustrine materials on the surface of the

till plain in these areas. The Hoytville series was split from the old Brookston series to cover these Humic-Gley soils. As work progressed it became apparent that the Paulding soils were developed from very fine-textured lacustrine materials, not very fine-textured till. The absence of any coarse fraction, the presence of laminations or varves in the lacustrine materials, and the presence of glacial clay till beneath the lacustrine materials supported this view.

A series of complete soil profiles were sampled along several transects to determine the soil characteristics (fig. 3). These transects were set up in such a manner that they crossed from the area of soils developed from clay till to the area of soils thought to be developed from lacustrine materials.

Transect A began in section 20 of Benton Township and ended in section 33 of Auglaize Township in Paulding County. Transect B began in section 19 of Hoaglin Township, Van Wert County, and extended to the extreme northwest corner of Putnam County. Transect C was originated in section 20 of Harrison Township and ended in section 24 of Emerald Township in Paulding County. A total of 25 complete soil profiles were taken along these three transects.

The results of the analyses of these samples together with additional information gathered in the field in Paulding and adjoining counties were used to develop and substantiate the soil-parent material relationships, to assist in the explanation of the variations in response to management and behavior of these soils, and to serve as an aid for separating the various soils in the field. The clay content of the subsoil along these transects ranged from 45 percent in those soils developed entirely from glacial clay till to more than 75 percent in those soils developed entirely from very fine-textured lacustrine materials. There are also major differences in structure and consistence in these various soil areas.

Hoytville Soils

Typical profiles of Hoytville soils in the Paulding Basin have a range in clay content of 45 to about 50 percent in the subsoil. Sand content varies from 12 to about 18 percent in both the subsoil and underlying till. The content of clay in the till varies from 40 to slightly less than 50 percent; the till contains a small but significant quantity of coarse skeleton consisting of Ohio shale, limestone, and igneous materials. The carbonate content ranges from 15 to 25 percent. The B horizons in these Hoytville profiles have weak textural development in terms of clay accumulation, whereas the angular blocky structure is strongly developed (Baker et al., in press).

Hoytville profile, VW-1, located 4 miles north of Van Wert in Hoaglin Township, Van Wert County, or in SW¼ SW¼ Section 19, T.3E., R.1S., on a slope of less than 1 percent was selected as being typical of the Hoytville series. Laboratory data are given in table 1. The description of this profile is as follows: (all Munsell color readings are for moist soil)

A_p	0– 8 in.	Very dark grayish brown (10YR 3/2) silty clay; weak fine angular blocky structure; firm when moist, very hard when dry; high organic matter content; lower boundary is abrupt.
B_{21g}	8–17 in.	Dark gray (10YR 4/1) clay with many, medium, distinct dark reddish brown (5YR 3/4) mottles; weak coarse prismatic structure which breaks into moderate fine angular blocky structure; firm when moist, very hard when dry; lower boundary is gradual.
B_{22g}	17–45 in.	Gray (10YR 5/1) clay with many, medium, distinct yellowish brown (10YR 5/6) and brown (7.5YR 4/4) mottles; strong medium angular blocky structure; firm when moist.
C_1	45–48 in.	Calcareous gray (10YR 5/1) and yellowish brown (10YR 5/6) clay till; massive; very firm when moist.
C_2	82–86 in.	Calcareous clay till similar to the above horizon.

Paulding Soils

Typical samples of Paulding soils have a range in clay content in the subsoil of 65 to more than 75 percent. Paulding soils have accumulated very little, if any, clay in their B horizons. The substratum beneath the solum contains as much or more clay than the subsoil. The amount of sand in the subsoil and substratum is usually less than 7 percent and is commonly less than 3 percent. There is no coarse skeleton present in the lacustrine material above the underlying clay till. The carbonate content varies from 15 to 25 percent.

These soils have moderate to well developed structure to depths of about 24 in. Below this point the soil structure is very poorly developed, if any has developed at all.

Paulding profile, PD-S8, located about three-quarters of a mile northwest of Junction in Emerald Township, Paulding County, or in SW¼ NW¼ Sec. 24, T.3N., R.3E., on a slope of less than 1 percent was selected as being typical of the Paulding series. Laboratory data are given in table 1. The description of this profile is as follows: (all Munsell color readings are for moist soil)

A_p	0– 6 in.	Dark gray (2.5Y 4/1) clay; massive to weak coarse granular structure; becomes more massive in lower 4 in.; firm when moist, extremely hard when dry, sticky and moderately plastic when wet; lower boundary is clear.
B_{1g}	6– 9 in.	Gray (N 5/0) fine clay with many, fine, distinct yellowish brown (10YR 5/8 to 6/8) mottles; massive to very weak fine angular blocky structure; very firm when moist, plastic and sticky when wet, extremely hard when dry; lower boundary is gradual.
B_{21g}	9–22 in.	Gray (N 5/0 to 4/0) fine clay with common, coarse, distinct yellowish brown (10YR 5/8) mottles; strong medium angular blocky structure; very firm when moist, sticky and plastic when wet, extremely hard when dry; lower boundary is gradual. (Sampled at 9–16 and 16–22 in.)
B_{22g}	22–30 in.	Gray (N 5/0) fine clay with many, fine, distinct yellowish brown (10YR 5/6) mottles; massive to weak angular blocky structure; very firm when moist, sticky and plastic when wet, extremely hard when dry; lower boundary is diffuse.
B_{3g}	30–48 in.	Gray (5Y 5/1 to 6/1) fine clay with many, fine, distinct yellowish brown (10YR 5/6) mottles; massive; very firm when moist, plastic and moderately sticky when wet; no roots evident; lower boundary is clear and wavy. (Sampled at 30–39 and 39–48 in.)
C_1	48–63 in.	Dark yellowish brown (10YR 4/4) calcareous fine clay with common, coarse, distinct gray (5Y 5/1) mottles and with coarse (one inch) light gray splotches of calcareous material; massive; very firm when moist.
C_2	63–80 in.	Yellowish brown (10YR 5/6) calcareous fine clay distinctly mottled with gray (N 5/0) on vertical faces and along laminae surfaces; weakly laminated, firm when moist.
C_2	80–90 in.	Olive brown (2.5Y 4/4) calcareous laminated fine clay mottled with gray (N 5/0) coatings on vertical faces and horizontally along laminae surfaces.
C_2	90–98 in.	Dark yellowish brown (10YR 4/3) calcareous laminated fine clay faintly mottled with gray (N 5/0) along laminae surfaces.

Latty Soils

An extensive belt, from 1 to 5 miles wide, occurs between the areas of typical Hoytville and typical Paulding soils in which the thickness of the lacustrine materials is rather thin—commonly less than 42 in. The soils in this area have

some of the characteristics of both Hoytville and Paulding soils. During average to dry weather they respond similarly to Hoytville soils; during wetter than average weather they have many of the characteristics of Paulding soils, but to a lesser degree. The Latty series was introduced during the survey of Paulding County for soils of this belt.

In this area the clay content of the subsoil ranges from 50 to about 60 percent, and that of the substratum varies from 40 to slightly above 50 percent. In some areas there is a sharp line of contact between the lacustrine materials and the underlying clay till. In other areas no contact line is evident because the two materials have been blended into a heterogenous mixture. The sand content in the subsoil varies from 8 to about 15 percent. The substratum contains 15 to 25 percent of carbonates. These soils have stronger development of structure in the lower part of the solum than Paulding soils but not quite as strong as that of Hoytville soils.

Latty profile, number 10, located 2 miles south of Paulding in Jackson Township, Paulding County or in SW¼ SW¼ Sec. 19, T.2N., R.3E., on a slope of less than 1 percent, was selected as being typical of the Latty series. Laboratory data are given in table 1. The description of this profile is as follows: (The Munsell color readings are for moist soil)

A_p 0– 7 in. Very dark gray (10YR 4/1) clay; massive to weak medium granular structure; very firm when moist, hard when dry; lower boundary is abrupt.

B_{21g} 7–18 in. Gray (2.5Y 6/1) clay with many, medium to coarse, prominent yellowish brown (10YR 5/6) mottles; moderate medium angular blocky structure; very firm when moist, sticky and plastic when wet; lower boundary is diffuse.

B_{22g} 18–32 in. Grayish brown (2.5Y 5/2) clay with many, medium to coarse, distinct yellowish brown (10YR 5/6) mottles; weakly developed prismatic structure that breaks into moderate coarse angular blocky structure; very firm when moist, plastic and sticky when wet; lower boundary is clear and wavy.

B_{23g} 32–40 in. Light olive gray (5Y 6/2) clay with common, medium, distinct yellowish brown (10YR 5/4) mottles; moderate medium and coarse angular blocky structure; very firm when moist, plastic and sticky when wet; lower boundary is clear.

C_1 40–48 in. Mottled yellowish brown to dark yellowish brown (10YR 5/6 to 4/4) gray to light gray (5Y 5/1 to 6/1) and white (2.5Y 8/2) calcareous clay; white material is $CaCO_3$ and occurs in patches in the mass; occasional small patches of very dark grayish brown (10YR 3/2) material; massive; very firm when moist; plastic when wet.

D 48–60 in. Gray to light gray (N 6/0) calcareous clay till mottled with dark yellowish brown (10YR 4/4) yellowish brown (10YR 5/6) and dark brown (10YR 4/2), gray makes up about 40 percent of the total mass; massive; very firm when moist, plastic when wet.

Toledo Soils

A more recent accumulation of lacustrine materials was deposited at some subsequent time over the lacustrine materials from which Paulding soils developed. The Toledo soils, developed from these younger materials, encompass an extensive area in eastern Paulding, the northwestern part of Putnam, and the southern part of Defiance Counties. They blend gradually into the Paulding soils surrounding them.

The Toledo soils have higher silt and lower clay content than the Paulding

soils. They also have thicker surface soils, stronger development of structure in the lower subsoil and respond more readily to tile drainage and other management practices. In some areas they are slightly stratified with thin lenses of fine sand.

The subsoil and upper substratum contains slightly less than 40 to about 55 percent of clay. Three Toledo profiles which were sampled to depths sufficient to reach nonconforming underlying materials indicate that the entire area is underlain with Paulding-like materials that contain 65 to more than 75 percent of clay at depths of 5 to 8 ft. These profiles reveal a rather sharp line of contact between these materials. Sand content of the Toledo soil material is usually less than 6 percent. The parent material contains 15 to 25 percent of carbonate. These soils have well developed structure throughout the solum.

Toledo profile, PD–2, located 3.5 miles northeast of Oakwood in Brown Township, Paulding County, or in NW¼ NE¼ Sec. 13, T.2N., R.4E., on a slope of less than 1 percent was selected as being typical of the Toledo series. Laboratory data are given in table 1. The description of this profile is as follows: (The Munsell color readings are for moist soil)

A_{11} 0– 3 in. Very dark gray (10YR 3/1) silty clay loam; moderate fine and medium subangular blocky structure; moderately firm when moist; very hard when dry.

A_{12} 3– 6 in. Very dark gray (10YR 3/1) silty clay with few, fine, faint olive (5Y 5/3) mottles; strong medium subangular blocky structure; moderately firm when moist, very hard when dry; lower boundary is clear.

B_{21g} 6–10 in. Dark gray to gray (5Y 4/1 to 5/1) silty clay with common, fine, faint yellowish brown (10YR 5/4) mottles; strong fine angular blocky structure; firm when moist; moderately plastic and slightly sticky when wet; lower boundary is gradual.

B_{22g} 10–28 in. Gray (N 5/0) silty clay with many, medium, prominent yellowish brown and brownish yellow (10YR 5/4 to 6/8) mottles; very strong, medium and coarse, angular blocky structure; very firm when moist, moderately plastic and slightly sticky when wet; lower boundary is gradual.

B_{23g} 28–36 in. Gray (5Y 6/1) silty clay with common, coarse, prominent yellowish brown (10YR 5/6) mottles; moderate medium prismatic structure which breaks into strong coarse angular blocky structure; very firm when moist, slightly plastic and slightly sticky when wet; lower boundary is gradual.

B_{24g} 36–54 in. Mottled gray (5Y 6/1) and yellowish brown (10YR 5/6) silty clay; weak medium angular blocky structure; firm when moist, slightly plastic when wet; lower boundary is clear and wavy.

C_1 54–57 in. Gray and yellowish brown calcareous silty clay of lacustrine origin; material is weakly laminated; firm when moist.

C_2 82–86 in. Gray and yellowish brown calcareous silty clay of lacustrine origin, finer textured than that above.

Other Observations

A number of observations in the field add additional support to the theory of very fine lacustrine deposits over clay till. One of the most striking of these observations was made on the high banks of the Little Auglaize River in Section 28 in Brown Township, Paulding County. At this point the river has scoured a sheer bank of about 25 ft in height into the upland soil materials. The very fine textured lacustrine deposits over the clay till are about 10 ft thick. They display well defined varves in the lower part of the materials. The contact between the very fine textured lacustrine materials and the clay till is very clear and sharp.

Within the area of lacustrine deposits are scattered knolls or ridges of till that project through the surface of the lacustrine mantle. These areas are easily recognized by the differences in the soils developed on them and the presence of pebbles common to the till. The soils are comparable to those developed from glacial till in the major part of the till plain, but they differ considerably from those soils developed from very fine-textured lacustrine materials in the immediate vicinity of the till island.

TABLE 1

Particle size distribution, pH, organic matter content and $CaCO_3$ equivalent of Paulding, Latty, Hoytville and Toledo soils

Horizon	Depth in in.	pH	Organic matter	$CaCO_3$ equiv-alent	Total sands 2–.05mm %	Silt .05–.002mm %	Clay <.002mm %	Texture class
Hoytville clay, VW–1								
A_p	0–8	6.5	5.5		15.3	40.5	44.2	silty clay
B_{21g}	8–17	6.5			15.9	37.4	46.7	clay
B_{22g}	17–45	7.2			13.9	36.0	50.1	clay
C_1	45–48	7.4			14.6	36.8	48.6	clay
C_2	82–86	8.0			21.0	38.1	40.9	clay
Paudling clay, PD–S8								
A_p	0–6	6.7	5.5		4.5	31.4	64.1	clay
B_{1g}	6–9	6.4	3.7		3.0	27.8	69.2	clay
B_{21g}	9–16	6.5			2.6	25.5	71.9	clay
B_{21g}	16–22	6.6			4.0	25.0	71.0	clay
B_{22g}	22–30	6.9			3.2	23.2	73.6	clay
B_{3g}	30–39	7.2			2.9	23.7	73.4	clay
B_{3g}	39–48	7.5		1.2	2.2	22.5	75.3	clay
C_1	48–63	8.1		18.9	3.7	30.7	65.6	clay
C_2	63–80	8.1		17.5	0.6	19.7	79.7	clay
C_2	80–90	7.9		18.2	0.4	18.4	81.2	clay
C_2	90–98	8.0		19.9	0.4	18.6	81.0	clay
Latty clay, PD–10								
A_p	0–7	6.6	5.2		12.7	38.6	48.7	clay
B_{21g}	7–18	7.1	1.9		10.9	31.3	57.8	clay
B_{22g}	18–32	7.4			10.8	30.4	58.8	clay
B_{23g}	32–40	7.6		2.1	11.2	28.0	60.8	clay
C_1	40–48	7.6		12.0	17.8	37.8	44.6	clay
D	48–60	7.7		22.0	16.4	43.8	39.8	silty clay loam
Toledo silty clay, PD–2								
A_{11}	0–3	6.7	9.9		3.0	59.3	37.7	silty clay loam
A_{12}	3–6	7.1	7.0		2.8	55.7	41.5	silty clay
B_{21g}	6–10	7.2	4.1		3.0	52.2	44.8	silty clay
B_{22g}	10–28	7.1	2.6		3.3	46.4	50.3	silty clay
B_{23g}	28–36	7.2			3.6	46.1	50.3	silty clay
B_{24g}	36–54	7.3			4.2	47.0	48.8	silty clay
C_1	54–57	7.7		5.4	5.5	51.5	43.0	silty clay
D	82–86	7.5		15.9	1.4	41.4	57.2	silty clay

The thickness of the very fine-textured lacustrine materials in the Paulding Basin varies from zero to more than 14 ft. Survey work revealed a significant difference in thickness of deposition from one point to another, but it is estimated

that most of that portion lying below an elevation of 725 ft has more than 4 ft of lacustrine deposits. One boring in Section 2, Washington Township, Paulding County, disclosed a depth of more than 14 ft to clay till. Many of the deeper examinations displayed the presence of varves or laminae in the lower part of the very fine textured lacustrine deposits.

The detailed soil survey of Paulding County and reconnaissance survey of adjoining areas reveal that there is a significant relationship of these lacustrine materials to general relief (fig. 2). The vast majority of Paulding soils lie below an elevation of 730 ft. Several small areas are found up to an elevation of 735 ft. The major portion of the Latty soils is present between elevations of 725 and 740 ft. Locally they have been mapped several feet above or below these elevations. The Hoytville soils rarely occur below an elevation of 735 ft in this basin. The Toledo soils are found in a broad uniform flat that lies at an elevation of 710 to slightly above 720 ft.

DISCUSSION

The relationship of the soils to the elevations at which they occur, the variations in thickness of the very fine-textured lacustrine materials, and the differences in the characteristics among the several soil series are significant. From the evidence presented it must be concluded that the center of this basin has accumulated a mantle of very fine-textured materials of lacustrine origin; that this mantle is quite variable in thickness; that this mantle, as evidenced by the Paulding and Toledo soils, has been deposited at two different times although these periods may not have been far apart; and that the soils derived from the thick lacustrine deposits (Paulding soils) vary somewhat from those developed from thin deposits over clay till (Latty soils). These three soils vary from the Hoytville soils developed from clay till. Figure 3 shows the relationship of the areas of occurrence of these soils.

The Hoytville and Toledo soils have A horizons that are 6 to 9 in. thick while those of Paulding soils usually vary between 4 and 6 in. in thickness. The thickness of the A horizon of Latty soils is intermediate between that of Hoytville and Paulding soils, usually 6 or 7 in.

Hoytville and Toledo soils on the average have darker colored A horizons than either Paulding or Latty soils. When they are moist, these soils usually have a very dark gray color (10YR 3/1) as determined by the Munsell color chart, but in some areas the color of Hoytville is very dark grayish brown (10YR 3/2). The color of the A horizon of Paulding and Latty soils is usually dark gray (10YR 4/1); in some areas it is slightly darker.

Hoytville and Toledo soils have strongly developed structure throughout their sola except for local areas where the structure is only moderately developed in the lower part of the B horizon. Paulding soils have moderately to strongly developed structure only to an average depth of 24 in. Below this depth the structure is very weakly developed or massive in the lower part of the solum. In the lower part of the B horizon of Latty soils the structure is more strongly developed than that of Paulding soils, but not as well developed as that of Hoytville soils.

The consistence of the B horizons of Hoytville and Toledo soils is firm or very firm when moist and slightly sticky and plastic when wet. The B horizons of Paulding and Latty soils are more firm when moist and more sticky when wet than those of Hoytville and Toledo soils. On drying the surface soils of Paulding and Latty become extremely hard; thus, they work up very cloddy. Hoytville and Toledo soils become hard on drying, but to a much lesser degree.

The soils derived from thin deposits of fine-textured lacustrine clay material have significant characteristics and behavior as compared with those developed entirely from clay till. The thicker deposits of very fine-textured lacustrine clays

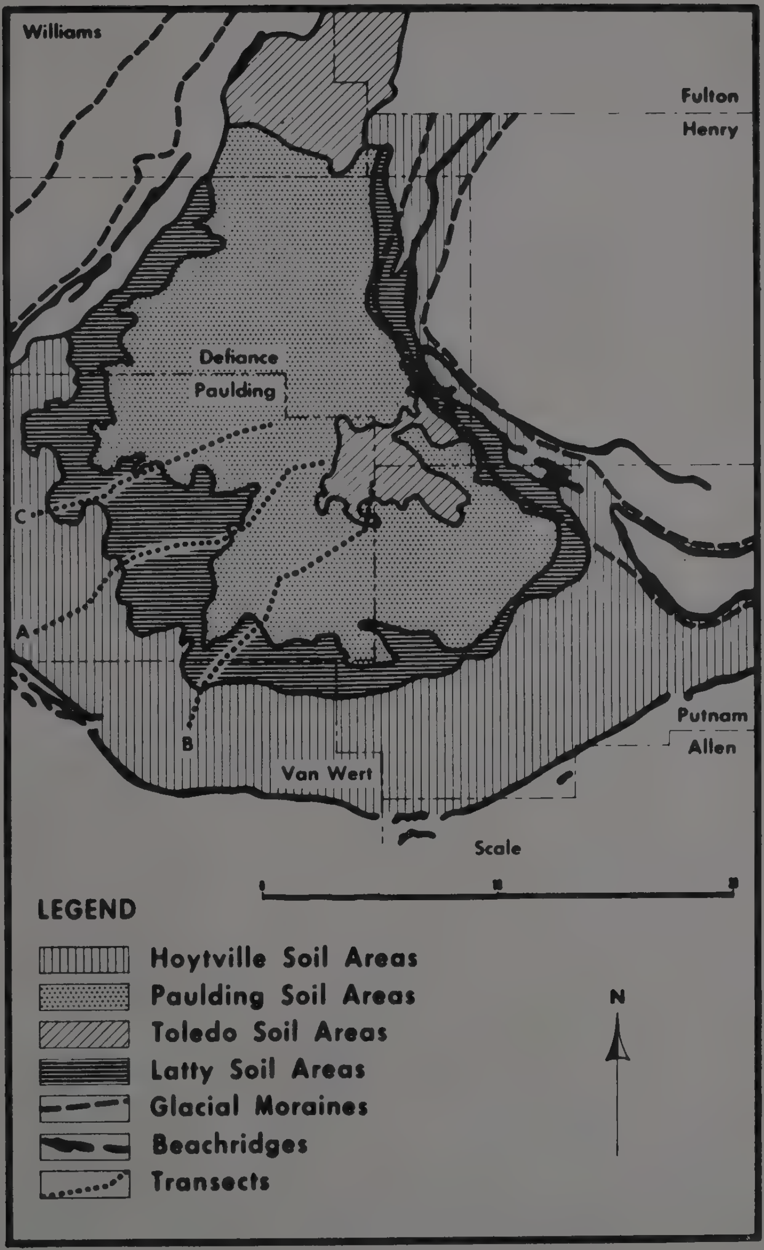

FIGURE 3. Distribution of Paulding, Latty, Hoytville, and Toledo soils, Paulding Basin, northwestern Ohio.

become highly significant in relation to soil characteristics when the lacustrine materials exceed a thickness of 42 to 48 in. and the clay content exceeds 60 to 65 percent. On the other hand the Toledo soils, developed entirely from fine-textured lacustrine materials, have many characteristics similar to those of Hoytville soils and are their equal in response to management. These soil characteristics are related to the higher silt and lower clay content than in the Paulding soils, better development of structure in the lower part of the solum, and the thicker, darker-colored surface horizons.

Both the Hoytville and Toledo soils respond readily to tile drainage and have very high productive capacity. Good seedbeds may be prepared on these soils; they produce very good stands of crops and high yields under average management.

The Paulding soils respond very slowly to tile drainage, and crops are drowned out frequently. They often have poor crop stands, even frequent complete crop failures. Because these soils work up very cloddy, seedbeds favorable to high germination and the establishment of good crop stands are very difficult to prepare. When Paulding soils become completely saturated and puddled following seeding, young plants either drown or cannot emerge because of severe crusting of the soil surface.

The Latty soils respond more like the Hoytville soils during favorable weather, but assume to a lesser degree many of the characteristics of Paulding soils during wet weather. They do not drain as readily as Hoytville soils, are somewhat more difficult to prepare into adequate seedbeds, and generally produce somewhat lower yields and have more crop failures than Hoytville soils.

THEORIES

Several theories have been developed concerning the nature of the till plain and the environment of deposition.

It is believed that the till plain where Hoytville soils are developed has been subjected to smoothing action by wave motion. Within the Hoytville soil areas are local places that display evidence of deposition, others where the presence of more than average pebble content at the surface indicates scouring action.

The area of deposition of lacustrine materials adds supporting evidence to this theory. Because areas of till, 1 to 10 acres in extent, project up through the mantle of lacustrine materials, it is postulated that lacustrine material was deposited in the early stages of the lake before the till plain was smoothed to a relatively level plain.

The source of materials with such a high clay content as in the area of Paulding soils is one of conjecture. Leverett and Taylor (1915) state that the glacier receded from the Fort Wayne moraine beyond the Defiance moraine, then re-advanced to the position of the Defiance moraine. At this position the first major stage of Lake Maumee came into being. The extent of beachridge development indicates that the first stage of Lake Maumee remained in this position for some time.

Since the Paulding materials overlay an unleveled till plain, they must have been deposited in the early stages of the lake system before wave action could have leveled the till plain. The first stage of Lake Maumee was the only one where Paulding-like lacustrine materials could have been deposited in such a confined area. Comparable materials are not known to occur in other parts of the lake plain in northwestern Ohio. There are similar lacustrine materials, but unrelated as to source, in the Killdeer Marsh area of Marion and Wyandot Counties.

When the glacier front was at the position of the Defiance moraine, two major river systems flowed into this lake, the Tiffin from the north and the Blanchard from the south. Both of these rivers were in position to receive large amounts of debris from the front of the melting ice.

The Tiffin River has a vast area of outwash plain extending into Michigan.

This plain from north to south has well-graded sediments that become finer as the center of the lake plain is reached. Just to the north of the Paulding materials are Toledo soil materials containing more silt and less clay.

The Blanchard River likewise left a large area of medium to moderately coarse textured materials immediately east of the Findlay Bay. However, it did not leave large areas of Toledo-like silty materials comparable to those in the Tiffin River Basin.

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Radiation Counters and Detectors. *C. C. H. Washtell.* Philosophical Library Inc., New York. 1960. $7.50.

The stated purpose of this book is "to provide a simple introduction to radiocative detectors and measurement techniques for . . . those possessing only a general scientific education." The author has succeeded for the most part. Early experiments and their importance are mentioned briefly as are the basic elements of atomic and nuclear structure. The main portion of this book is devoted to the principles of operation of the better known radiation detectors. Some space is devoted to special purpose detectors for workers in a variety of fields using radio-isotopes. Fortunately, the author, although British, has restricted himself to using only a few of the technical terms that differ on opposite sides of the Atlantic (e.g., "valve" for "vacuum tube" and "lead castle" for "lead shield").

Perhaps too many pages are devoted to details of construction techniques since this book is an introduction to the subject. Twenty-two pages are in tabular form listing commercially available detectors of various types along with some of their characteristics. Unfortunately, of the eight suppliers mentioned by the author, only one is not British and hence most of the detectors mentioned are not readily available in this country. The book is liberally illustrated with 36 diagrams and 16 half-tone plates (most of them photographs).

The book is probably not suitable as a textbook for most laboratory courses, but it could be valuable to a worker contemplating the use of radioisotopes in his field. The author has supplied a clear, elementary discussion of the subject.

WALTER E. CAREY

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